4156K and 4166K Series Temperature Controllers

Contents


W3525-1/IL

Figure 1. Controller Yoke-Mounted on Control Valve Actuator

Introduction

Scope of Manual

This instruction manual provides installation, operating, maintenance, and parts information for the 4156K and 4166K Series Wizard® II temperature controllers (figure 1). Refer to separate instruction manuals for information regarding the control valve, actuator, and accessories.

Do not install, operate, or maintain a 4156K or 4166K Series temperature controller without first • being fully trained and qualified in valve, actuator and accessory installation, operation and maintenance and • carefully reading and understanding the contents of this manual. If you have any questions about these instructions, contact your Emerson Process Management™ sales office.

Description

The 4156K and 4166K Series pneumatic temperature controllers use a temperature bulb immersed in the process fluid to increase or decrease pressure in the temperature element's Bourdon tube as the temperature of the process fluid increases or decreases. The controller output is a pneumatic signal that operates a final control element to minimize deviation between the process temperature and an operator-adjusted set point.

Educational Services

For information on available courses for 4156K and 4166K Series temperature controllers, as well as a variety of other products, contact:

Emerson Process Management
Educational Services, Registration
P.O. Box 190; 301 S. 1st Ave.
Marshalltown, IA 50158−2823
Phone: 800−338−8158 or
Phone: 641−754−3771
FAX: 641−754−3431
e-mail: education@emersonprocess.com

Table 1. Available Configuration

Type Number[1]	Proportional-Only	Proportional-Plus-Reset	Differential Gap	Anti-Reset Windup
4156K	X			
4156KS			X	
4166K		X		
4166KF		X		X

1. Reverse-acting constructions are designated by an R suffix in the type number.

Specifications

Specifications for the 4156K and 4166K Series controllers are listed in table 2. Table 1 explains available configurations and options.

WARNING

This product is intended for a specific range of pressure, temperatures and other application specifications. Applying different pressure, temperature and other service conditions could result in malfunction of the product, property damage or personal injury.

Note

Neither Emerson, Emerson Process Management, nor any of their affiliated entities assumes responsibility for the selection, use, or maintenance of any product. Responsibility for the selection, use, and maintenance of any product remains with the purchaser and end-user.

Table 2. Specifications

Available Configurations

See table 1

Input Signal

Type: Temperature between 0°C and 500°C or 0°F and 1000°F; see table 4 for available ranges
Minimum Span: 100°C or 100°F
Maximum Span: 500°C or 1000°F

Output Signal

Proportional or Proportional-Plus-Reset Controllers:

■ 0.2 to 1.0 bar (3 to 15 psig) or
■ 0.4 to 2.0 bar (6 to 30 psig) pneumatic pressure signal

Differential Gap Controllers:

■ 0 and 1.4 bar (0 and 20 psig) or
■ 0 and 2.4 bar (0 and 35 psig) pneumatic pressure signal

Action: Control action is field reversible between ■ direct (increasing sensed temperature produces increasing output signal, and ■ reverse (increasing sensed temperature produces decreasing output signal). The suffix R is added to the type number of a construction specified for reverse action

Supply Pressure(1)

See table 3

Supply Pressure Medium

Air or natural gas

Air Quality: Supply pressure must be clean, dry air that meets the requirements of ISA Standard 7.0.01. A maximum 40 micrometer particle size in the air system is acceptable. Further filtration down to 5 micrometer particle size is recommended. Lubricant content is not to exceed 1 ppm weight (w/w) or volume (v/v) basis. Condensation in the air supply should be minimized

Natural Gas: Natural gas must be clean, dry, oil-free, and noncorrosive. H_2S content should not exceed 20 ppm.

Steady-State Air Consumption

See figure 2

Supply and Output Connections

1/4 NPT internal

Common Signal Pressure Conversions

See table 5

Maximum Allowable Pressure in Closed Vessel (For Temperature Bulb)(1)

10 mm (3/8-inch) Temperature Bulb: 69 bar (1000 psig) at 38°C (100°F)
14 mm (9/16-inch) Temperature Bulb: 34.5 bar (500 psig) at 38°C (100°F)

Proportional Band Adjustment

For Proportional or Proportional-Plus-Reset Controllers: Full output pressure change adjustable over percent of sensing element temperature range as follows:

Proportional:

■ 3% to 100% [0.2 to 1.0 bar (3 to 15 psig)] or
■ 6% to 100% [0.4 to 2.0 bar (6 to 30 psig)]

Proportional-Plus-Reset:

■ 6% to 200% [0.2 to 1.0 bar (3 to 15 psig)] or
■ 12% to 200% [0.4 to 2.0 bar (6 to 30 psig)]

Differential Gap Adjustment

For Differential Gap Controllers: Full output pressure change adjustable from 15% to 100% of sensing element temperature range

Reset Adjustment (Types 4166K and 4166KF Controllers Only)

Adjustable from 0.01 minutes to more than 74 minutes per repeat (from 100 repeats per minute to less than 0.0135 repeats per minute)

Performance

Repeatability: 0.5% of sensing element temperature span
Dead Band (Except Differential Gap Controllers(2)): 0.1% of output span
Time Constant of Temperature Bulb: 9 to 18 seconds (bare bulb in agitated liquid)
Vibration Sensitivity: Unaffected at usual motor and turbine speeds

Ambient Operating Temperature Limits(1)

–40° to 71°C (–40 to 160°F)

– Continued –

Table 2. Specifications (Continued)

Typical Ambient Temperature Operating Influence

Proportional Control only: ±3% of output span for each 28°C (50°F) change in temperature for a controller set at 100% proportional band
Reset Control only: ±2% of output span for each 28°C (50°F) change in temperature for a controller set at 100% proportional band

Process Temperature Indication

Standard on all controllers and calibrated for the temperature range ordered

Exterior Tubing

Standard: 6.4 mm (1/4-inch)
Optional: 9.5 mm (3/8-inch)

Capillary Lengths

Standard: 4.6 m (15-foot)
Optional: Consult your Emerson Process Management sales office for other lengths

Hazardous Area Classification

Complies with the requirements of ATEX Group II Category 2 Gas and Dust

CE Ex II 2 G D

Refer to figure 3 for location of ATEX label

Approximate Weight

8.2 kg (18 pounds)

Declaration of SEP

Fisher Controls International LLC declares this product to be in compliance with Article 3 paragraph 3 of the Pressure Equipment Directive (PED) 97 / 23 / EC. It was designed and manufactured in accordance with Sound Engineering Practice (SEP) and cannot bear the CE marking related to PED compliance.

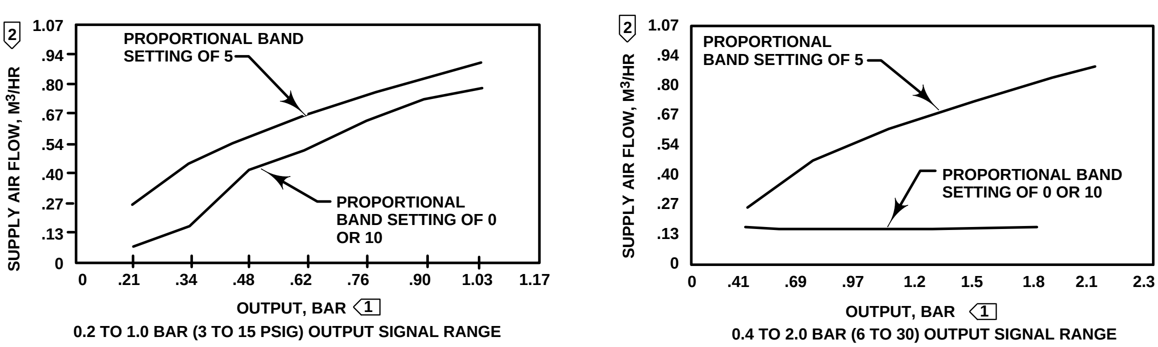
However, the product *may* bear the CE marking to indicate compliance with *other* applicable European Community Directives.

NOTE: Specialized instrument terms are defined in ANSI/ISA Standard 51.1 – Process Instrument Terminology.
1. The pressure/temperature limits in this document and any applicable standard or code limitation should not be exceeded.
2. An adjustable differential gap (differential gap controllers) is equivalent to an adjustable deadband.

Table 3. Supply Pressure Requirements

OUTPUT SIGNAL RANGE		NORMAL OPERATING SUPPLY PRESSURE(1)	MAXIMUM ALLOWABLE SUPPLY PRESSURE TO PREVENT INTERNAL PART DAMAGE(2)
Bar	0.2 to 1.0 or 0 and 1.4 (differential gap)	1.4	2.8
	0.4 to 2.0 or 0 and 2.4 (differential gap)	2.4	2.8
Psig	3 to 15 or 0 and 20 (differential gap)	20	40
	6 to 30 or 0 and 35 (differential gap)	35	40

1. If this pressure is exceeded, control may be impaired.
2. If this pressure is exceeded, damage to the controller may result.



NOTES
1 TO CONVERT BAR TO PSIG DIVIDE BY 0.06895.
2 M3/HR-NORMAL CUBIC METERS PER HOUR (0°C AND 1.01325 BAR, ABSOLUTE) TO CONVERT TO SCFH-STANDARD CUBIC FEET PER HOUR (60°F AND 14.7 PSIG) DIVIDE BY 0.0268
E0473 / IL

Figure 2. Steady-State Air Consumption

Table 4. Temperature Ranges of Temperature Element Assemblies(1)

TEMPERATURE SPAN, °C	TEMPERATURE RANGE, °C	OVERRANGE LIMITS(2) 4.6 m (15 Foot) Capillary Tube °C
100	0 to 100	200
150	0 to 150	200
200	0 to 200	330
250	0 to 250	500
300	0 to 300	500
400	0 to 400	500
500	0 to 500	600
TEMPERATURE SPAN, °F	**TEMPERATURE RANGE, °F**	**°F**
100	0 to 100 50 to 150 100 to 200	200 225 250
150	50 to 200	370
200	0 to 200 50 to 250	470 435
300	0 to 300	400
400	0 to 400	780
600	0 to 600	870
800	0 to 800	1000
1000	0 to 1000	1200

1. Class IIIB per SAMA Standard RC6-10.
2. If these limits are exceeded, a permanent zero shift may result.

Table 5. Common Signal Pressure Conversions

PSI	kPa	bar	kg/cm2	Mpa
3	20(1)	0.2(2)	0.2	0.02
5	35	0.3	0.4	0.03
6	40(1)	0.4	0.4	0.04
7	50	0.5	0.5	0.05
9	60	0.6	0.6	0.06
11	75	0.8	0.8	0.07
12	80	0.8	0.8	0.08
14	95	1.0	1.0	0.09
15	100(1)	1.0(2)	1.0(3)	0.10
18	125	1.2	1.3	0.12
20	140	1.4	1.4	0.14
22	150	1.5	1.5	0.15
25	170	1.7	1.8	0.17
27	185	1.9	1.9	0.18
30	200(1)	2.0(3)	2.0	0.20
32	220	2.2	2.2	0.22
33	230	2.3	2.3	0.23
35	240	2.4	2.5	0.24
50	345	3.4	3.5	0.34
80	550	5.5	5.6	0.55
100	690	6.9	7.0	0.69
150	1035	10.3	10.5	1.03

1. Values as listed in ANSI/ISA S7.4.
2. Values as listed in IEC Standard 382.
3. Values rounded to correspond with kPa values.

Installation

Standard Installation

The controller is normally mounted vertically with the case/cover as shown in figure 1. If installing the controller in any other position, be sure that the vent opening, shown in figure 3, is facing downward. (Note: see the pipestand mounting showing the right side view.)

WARNING

Avoid personal injury from sudden release of process pressure. Before mounting the controller:

- **Always wear protective clothing, gloves, and eyewear when performing any installation operations to avoid personal injury.**
- **Personal injury or property damage may result from fire or explosion if natural gas is used as the supply medium and preventative measures are not taken. Preventative measures may include: Remote venting of the unit, re-evaluating the hazardous area classification, ensuring adequate ventilation, and the removal of any ignition sources. For information on remote venting of this controller, refer to page 8.**
- **If installing into an existing application, also refer to the WARNING at the beginning of the Maintenance Section of this instruction manual.**
- **Check with your process or safety engineer for any additional measures that must be taken to protect against process media.**

Panel Mounting

Cut a hole in the panel surface according to the dimensions shown in figure 3. Remove cap screws (key 252), brackets (key 251, figure 3), and vent (key 15). For Type 4166KF controllers, on the anti-reset windup differential relief valve, note the direction the arrow is pointing and remove the relief valve.

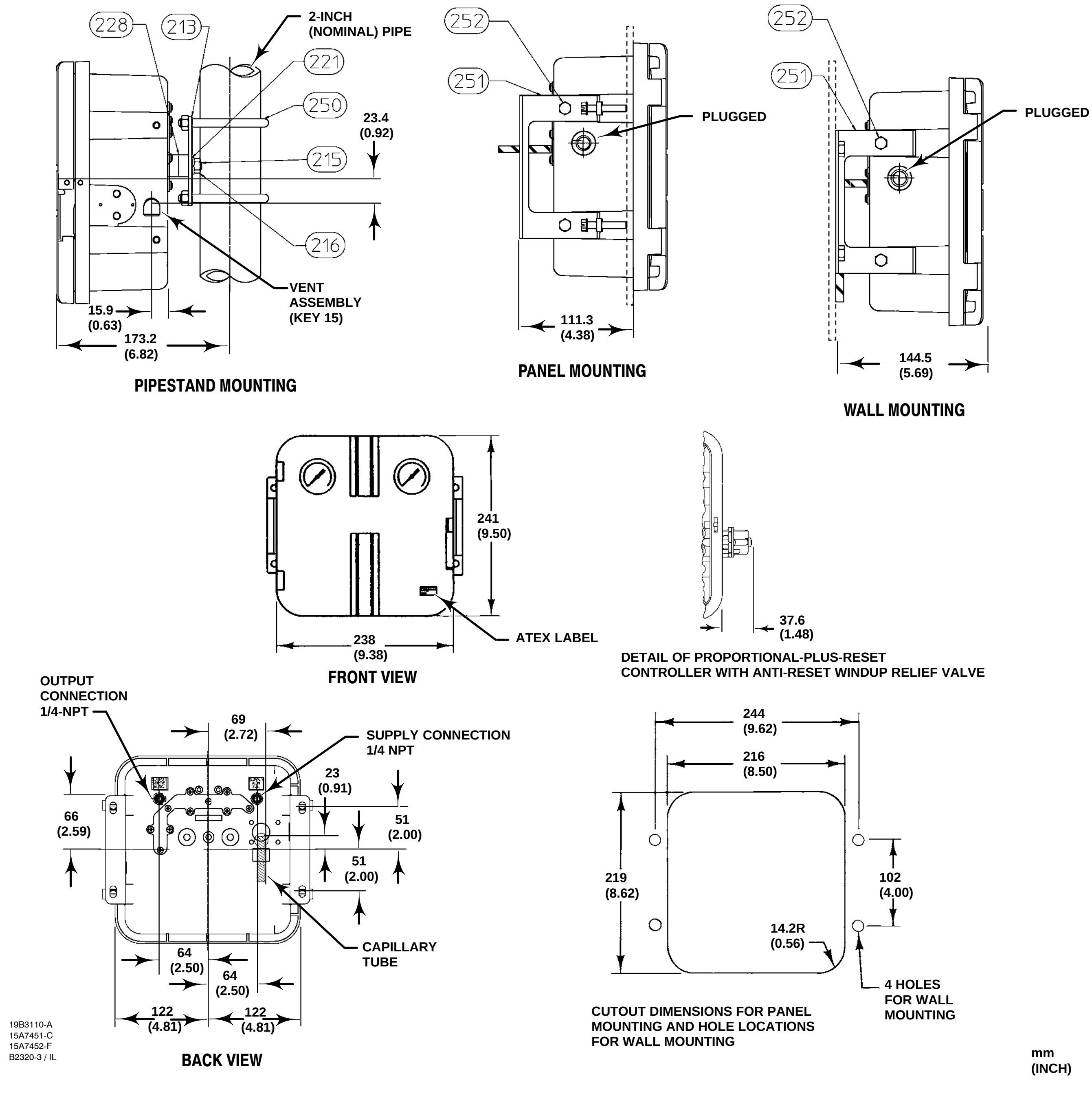


Figure 3. Panel, Wall, and Pipestand Mounting

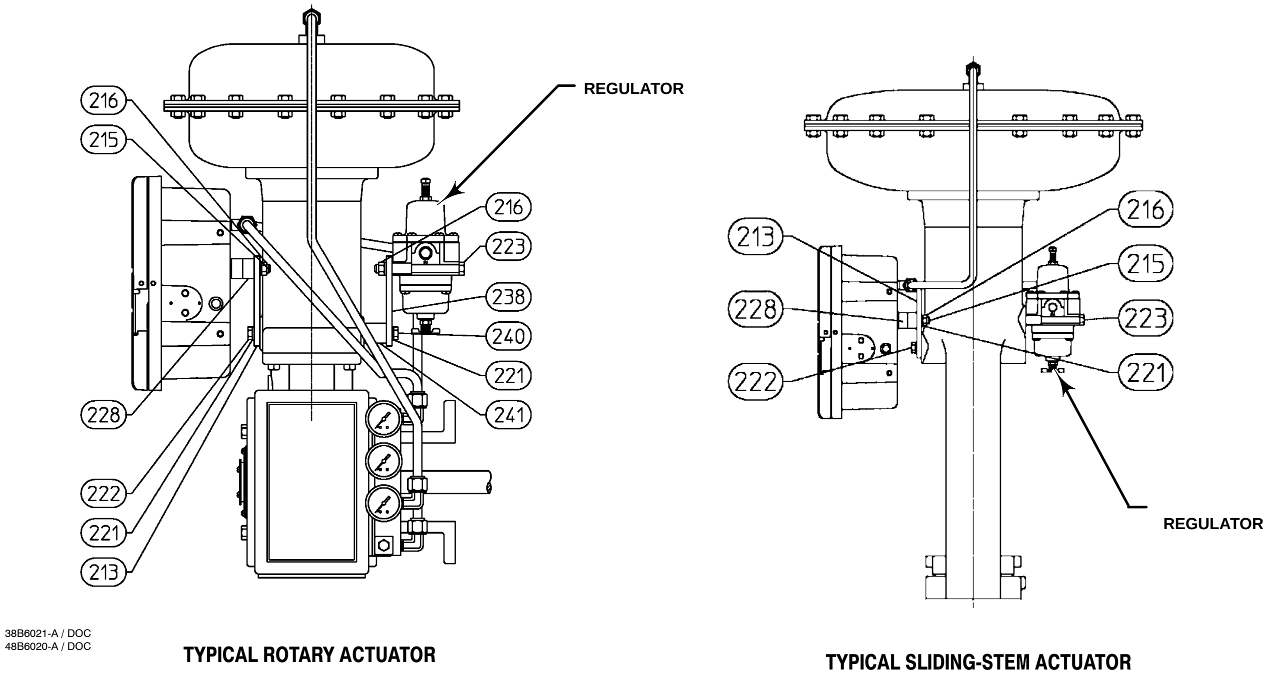


Figure 4. Actuator Mounting

Slide the controller into the cutout and re-attach the brackets. Tighten the cap screws on each bracket to draw the case snugly and evenly around the panel. Reinstall the vent unless the vent connection is to be piped away. For Type 4166KF controllers, reinstall the differential relief valve with the arrow pointing in the same direction as noted above.

Wall Mounting

Drill four holes in the wall using the dimensions shown in figure 3. In the bracket (key 251, figure 3) are 8.7 mm (11/32-inch) diameter holes. Remove the two cap screws located on each bracket. These screws are used for panel mounting and are not required for wall mounting. If the capillary tube is to run through the wall, drill a hole in the wall large enough to accept the temperature bulb (see figure 5 for bulb dimensions, and figure 6 for bushing or thermowell dimensions). Refer to the back view in figure 3 for the location of the capillary tube connection in the back of the case.

Mount the controller to the bracket using four cap screws (key 252). Attach the bracket to the wall, using suitable screws or bolts.

Pipestand Mounting

Attach the spacer spools (key 228) and the mounting plate to the controller with cap screws, lock washers, and nuts (keys 215, 221, and 216, figure 3). Attach the controller to a 2-inch (nominal) pipe with pipe clamps (key 250).

Actuator Mounting

Controllers specified for mounting on a control valve actuator are mounted at the factory (see figure 4). If the controller is ordered separately for installation on a control valve actuator, mount the controller according to the following instructions.

Mounting parts for various actuator types and sizes vary. Two typical actuator-mounted installations are shown in figure 4. See the parts list for parts required by the specific actuator type and size involved. Attach the spacer spools (key 228) and the mounting plate (key 213) to the controller with machine screws, lock washers, and nuts (keys 215, 221, and 216). Attach the mounting plate to the actuator yoke with cap screws (key 222) and, if needed, spacer spools. On some designs, the mounting bracket is attached to the actuator diaphragm casing rather than to the yoke.

Pressure Connections

WARNING

To avoid personal injury or property damage resulting from the sudden release of pressure, do not install any system component where service conditions could exceed the limits given in this manual. Use pressure-relieving devices as required by government or accepted industry codes and good engineering practices.

All pressure connections on 4156K and 4166K Series controllers are 1/4 NPT internal. Use 6 mm (1/4-inch) or 10 mm (3/8-inch) pipe or tubing for supply and output piping. Use 13 mm (1/2-inch) pipe for the remote vent pipe, if one is required. Locations of pressure connections are shown in figure 3.

Supply Pressure

WARNING

Severe personal injury or property damage may occur if the instrument air supply is not clean, dry and oil free. While use and regular maintenance of of a filter that removes particles larger than 40 microns in diameter will suffice in most applications, check with an Emerson Process Management field office and instrument industry air quality standards for use with corrosive gas or if you are unsure about the proper amount or method of air filtration or filter maintenance.

Supply pressure must be clean, dry air or noncorrosive gas that meets the requirements of ISA Standard 7.0.01. A maximum 40 micrometer particle size in the air system is acceptable. Further filtration down to 5 micrometer particle size is recommended. Lubricant content is not to exceed 1 ppm weight (w/w) or volume (v/v) basis. Condensation in the air supply should be minimized. Alternatively, natural gas may be used as the supply pressure medium. Gas must be clean, dry, oil-free, and noncorrosive. H_2S content should not exceed 20 ppm.

Use a suitable supply pressure regulator and filter to reduce the supply pressure source to the normal operating supply pressure shown in table 3. Connect supply pressure to the SUPPLY connection at the back of the case.

Vent

WARNING

Personal injury or property damage could result from fire or explosion of accumulated gas, of from contact with hazardous gas, if a flammable or hazardous gas is used as the supply pressure medium. Because the instrument case and cover assembly do not form a gas-tight seal when the assembly is enclosed, a remote vent line, adequate ventilation, and necessary safety measures should be used to prevent the accumulation of flammable or hazardous gas. However, a remote vent pipe alone cannot be relied upon to remove all flammable and hazardous gas. Vent line piping should comply with local and regional codes and should be as short as possible with adequate inside diameter and few bends to reduce case pressure buildup.

CAUTION

When installing a remote vent pipe, take care not to overtighten the pipe in the vent connection. Excessive tightening will damage the threads in the connection.

The vent (key 15, figure 3) or the end of a remote vent pipe must be protected against the entrance of all foreign matter that could plug the vent. Use 13 mm (1/2-inch) pipe for the remote vent pipe, if one is required. Check the vent periodically to be certain it has not become plugged.

Table 6. Maximum Process Pressures for Thermowells

THERMOWELL SIZE	TEMPERATURE BULB DIAMETER		MATERIAL	TEMPERATURE °C (°F)											
				21 (70)		93 (200)		204 (400)		316 (600)		427 (800)		538 (1000)	
	mm	Inch		Bar	Psig	Bar	Psig	Bar	Psig	Bar	Psig	Bar	Psig	Bar	Psig
1/2 NPT	10	3/8	Carbon steel	218.0	3160	209.8	3040	200.1	2900	191.1	2770	145.6	2110	—	—
			304 SST	284.3	4120	258.1	3740	234.6	3400	226.3	3280	219.4	3180	189.8	2750
			316 SST	284.3	4120	284.3	4120	265.7	3850	259.4	3760	253.9	3680	212.5	3080
			N04400	263.6	3820	243.6	3530	224.3	3250	221.5	3210	215.9	3130	—	—
3/4 NPT	10	3/8	Carbon steel	358.8	5200	345.0	5000	331.2	4800	317.4	4600	241.5	3500	—	—
			304 SST	483.0	7000	427.8	6200	386.4	5600	372.6	5400	358.8	5200	310.5	4500
			316 SST	483.0	7000	483.0	7000	441.6	6400	427.8	6200	441.6	6100	351.9	5100
			N04400	448.5	6500	414.0	6000	372.6	5400	365.7	5300	358.8	5200	—	—
3/4 NPT	14	9/16	Carbon steel	159.4	2310	140.1	2030	131.1	1900	125.6	1820	98.7	1430	—	—
			304 SST	239.4	3470	212.5	3080	173.9	2520	167.7	2430	127.7	1850	112.5	1630
			316 SST	239.4	3470	239.4	3470	223.6	3240	217.4	3150	213.9	3100	179.4	2600
			N04400	211.8	3070	173.2	2510	169.7	2460	166.3	2410	148.4	2150	—	—

Table 7. Maximum Process Fluid Velocities(1) for Thermowells

THERMOWELL SIZE	TEMPERATURE BULB DIAMETER		MATERIAL	INSERTION LENGTH(2), mm (INCHES)							
				191 (7.5)		267 (10.5)		406 (16)		610 (24)	
	mm	Inch		m/s	Feet/s	m/s	Feet/s	m/s	Feet/s	m/s	Feet/s
1/2 NPT	10	3/8	Carbon steel	14.6	48	7.6	25	3.4	11	—	—
			304 stainless steel/316 stainless steel	15.2	50	7.9	26	3.4	11	—	—
			N04400	14.6	48	7.3	24	3.4	11	—	—
3/4 NPT	10	3/8	Carbon steel	21.0	69	10.7	35	4.6	15	—	—
			304 stainless steel/316 stainless steel	21.9	72	11.3	37	4.9	16	—	—
			N04400	20.7	68	10.7	35	4.6	15	—	—
3/4 NPT	14	9/16	Carbon steel	29.6	97	14.9	49	6.4	21	3.0	10
			304 stainless steel/316 stainless steel	30.5	100	15.5	51	6.7	22	3.0	10
			N04400	28.9	95	14.9	49	6.4	21	2.7	9

1. For gas, air, or steam. Values may be lower for liquids.
2. This is the U dimension in figure 6.

Temperature Sensing Bulb, Bushings, Thermowells

WARNING

Do not subject the thermowell to process pressure and velocity in excess of the values listed in tables 6 and 7. Failure of the thermowell may result in personal injury or equipment damage caused by escaping process fluid.

Process temperature is sensed by a temperature bulb immersed in the process fluid. When the temperature bulb (figure 5) is to be used within a closed vessel, bushings are available to attach the bulb to the vessel.

The bushing (dimensions are shown in figure 6) penetrates the vessel and the temperature bulb screws into the bushing. If the process temperature exceeds the limits of the temperature bulb, or if the process fluid is corrosive, a thermowell (dimensions are shown in figure 6) penetrates the vessel and the temperature bulb screws into the thermowell. Table 6 lists the maximum process pressure/temperature ratings for thermowells. Table 7 lists velocity ratings for thermowells for process fluid velocities such as encountered if the thermowell is mounted in a pipe.

With the controller mounted so the temperature bulb reaches the process, screw the bulb into the bushing or thermowell.

If the temperature bulb is to be installed in a pipe, process velocity is an important consideration. Install the bulb where the process temperature is to be measured, keeping in mind the velocity limits shown in table 7. Tapered thermowells, built to withstand even greater process velocities, are also available.

SAMA STYLE	TEMPERATURE SPAN		DIMENSION					
	°C	°F	J		X		Y	
			mm	Inch	mm	Inch	mm	Inch
Adjustable Union (Standard Construction)	0-100 0-150	0-100 200-400	445	17.50	145	5.70	10	0.38
	0-200 0-500	0-400 0-1000	584	23.00	178	7.00	14	0.56

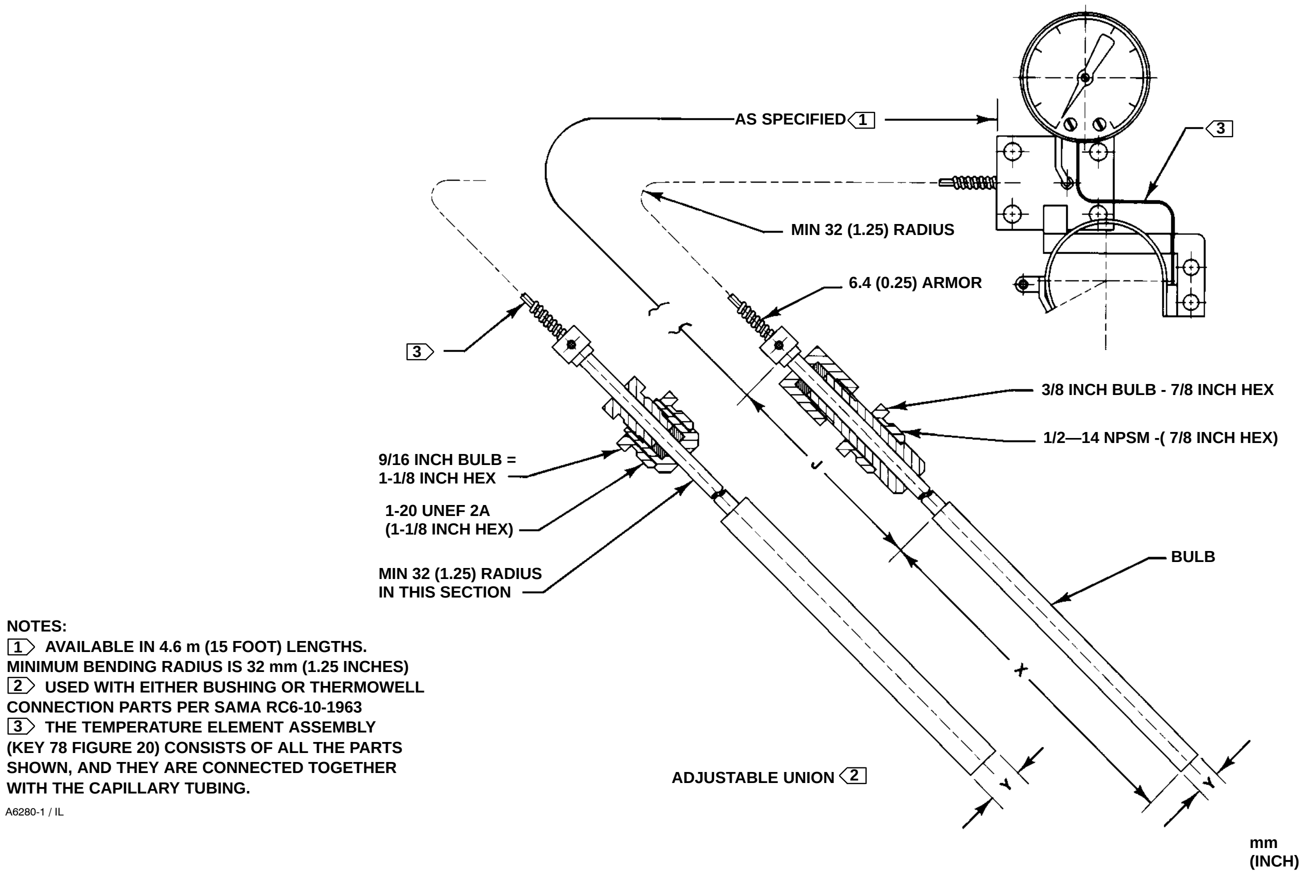
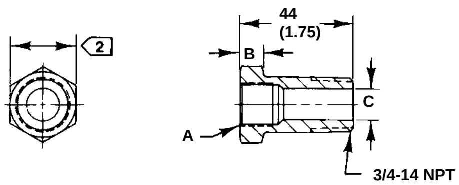
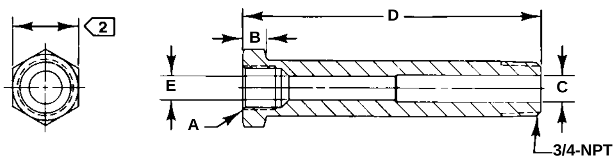


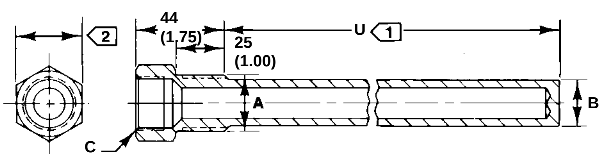
Figure 5. Temperature Element Dimensions



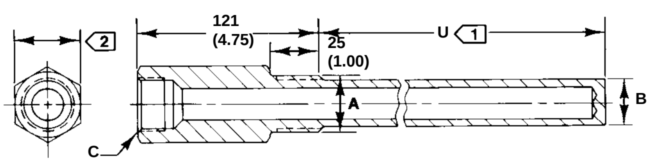
BUSHINGS WITHOUT LAGGING



BUSHINGS WITH LAGGING



THERMOWELLS WITHOUT LAGGING



THERMOWELLS WITH 76 mm (3-INCH) LAGGING

NOTES:
1 TOLERANCES FOR THIS DIMENSION ARE AS FOLLOWS:
1.5 mm (±0.06 INCH) WHEN LENGTH IS 305 mm (12 INCHES) OR LESS
3.2 mm (±0.125 INCH) WHEN LENGTH IS GREATER THAN 305 mm (12 INCHES)
2 1-1/8 INCH HEX FOR 3/8-INCH TEMPERATURE BULB;
1-1/4 INCH HEX FOR 9/16-INCH TEMPERATURE BULB
A3240-3* / IL

Bushings without Lagging

TEMPERATURE BULB DIAMETER		DIMENSION				
		A(1)	B		C	
mm	Inch		mm	Inch	mm	Inch
10	3/8	1/2-14 NPSM	11	0.44	11	0.44
14	9/16	1-20 UNEF	19	0.75	16	0.63

1. Seat area per SAMA Standard RC-17-10.

Bushings with Lagging

TEMPERATURE BULB DIAMETER		DIMENSION								
		A(1)	B		C		D		E	
mm	Inch		mm	Inch	mm	Inch	mm	Inch	mm	Inch
10	3/8	1/2-14 NPSM	11	0.44	12	0.47	113	4.44	11	0.44
14	9/16	1-20 UNEF	19	0.75	17	0.66	121	4.75	16	0.63

1. Seat area per SAMA Standard RC-17-10.

Thermowell Dimensions

TEMPERATURE BULB DIAMETER		DIMENSION					
		A	B		C(1)	U (Insertion Length)	
mm	Inch		mm	Inch		mm	Inch
10	3/8	1/2-14NPT 3/4-14NPT	16 20	0.63 0.77	1-20 UNEF-2B	191 267 406	7.5 10.5 16.0
14	9/16	3/4-14NPT	22	0.88	1-20 UNEF-2B	191 267 406 559	7.5(2) 10.5 16.0 24.0

1. Seat area per SAMA Standard RC-17-10.
2. Lagged thermowell only.

Figure 6. Bushing and Thermowell Dimensions

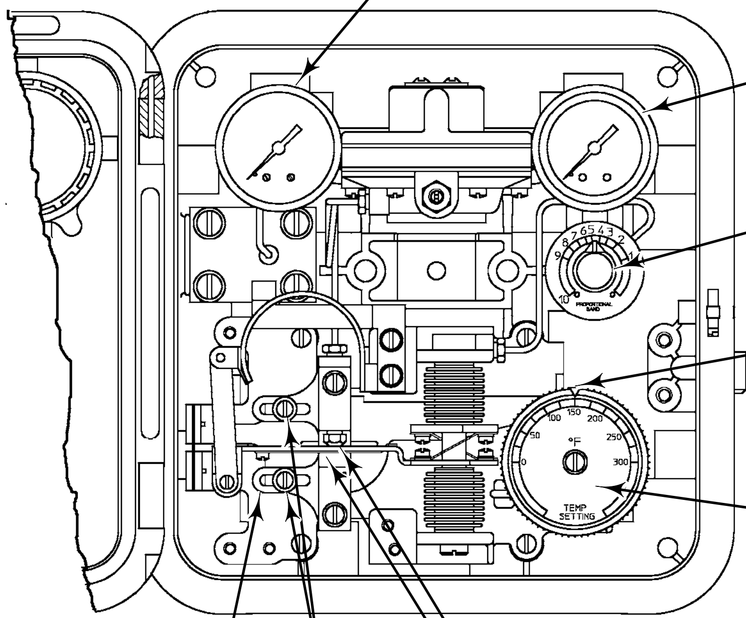


Figure 7. Location of Adjustments, Proportional-Only Controller

Controller Operation

Description of Temperature Baths

The calibration procedures require that the process temperature be simulated. A temperature bath (liquid or sand, depending on temperature requirements) is recommended. The temperature bath should be able to cover 0 to 100 percent of the temperature element input range for the most accurate calibration.

If available, two baths will simplify and speed up the calibration process. The minimum bath should be preset at 0 percent of input range and the maximum bath should be set at 100 percent of input range.

Also, provide a means of measuring bath temperature. Use a thermometer or resistance temperature detector (RTD).

Proportional-Only Controllers

This section describes the adjustments and procedures for calibration and startup. Adjustment locations are shown in figure 7 unless otherwise specified. All adjustments must be made with the cover open. When the adjustments and calibration procedures are complete, close and latch the cover.

To better understand the adjustments and overall operation of the controller, refer to the Principle of Operation section in this manual for proportional-only controllers. Refer also to the controller schematic diagram (figure 14).

Adjustments

Adjustment: Set Point

The temperature setting knob is constructed with a white triangular indicator that moves along the edge of the “TEMP SETTING” dial. The white triangle is attached to the black knob surrounding the dial. Turn the temperature setting knob clockwise to increase the temperature set point, or counterclockwise to decrease the set point. Note: The dial setting and actual process temperature may vary significantly, especially with a wide proportional band setting.

Adjustment: Proportional Band

Adjust the proportional band by rotating the proportional band knob to the desired value.

The proportional band adjustment determines the sensitivity (gain) of the controller, i.e., it determines the amount of change in the process temperature required to change the controller output signal from one limit of the output range to the other limit. It may be adjusted from 3 to 100 percent of the nominal temperature bulb range for a 0.2 to 1 bar (3 to 15 psig) output, or 6 to 100 percent for a 0.4 to 2 bar (6 to 30 psig) output.

Calibration of Proportional-Only Controllers

The controller is calibrated at the factory and should not need additional adjustment for most processes. Use the following bench calibration procedures when the sensing element has been changed or other maintenance procedures have altered the calibration of the controller. If you wish to use the factory calibration without performing the following calibration procedure, proceed to the Startup: Proportional Controllers (General Tuning Guidelines) subsection in this section.

WARNING

To avoid personal injury or property damage caused by the release of pressure or process fluid, observe the following before starting calibration:

- **Provide some temporary means of control for the process before taking the controller out of service.**
- **Vent any trapped process pressure from both sides of the control valve.**
- **Use lock-out procedures to be sure that the above measures stay in effect while you are working on the equipment.**
- **Check with your process or safety engineer for any additional measures that must be taken to protect against process media.**

Bench Calibration: Proportional-Only Controllers

Unless otherwise indicated, key number and part locations are shown in figure 7.

Refer to the description of temperature baths at the start of the Controller Operation section. Provide a temperature source capable of simulating the process temperature range of the controller.

Note

If a maximum temperature bath with a temperature equal to the upper range limit of the temperature element bulb is not available, use any temperature that is available within the range. Then, adjust the set point to the temperature of the bath.

Connect a pressure source to the supply pressure regulator, and be sure the regulator is delivering the correct supply pressure to the controller. The controller must be connected open loop (Open loop: The controller output pressure changes must be dead ended into a pressure gauge). The following procedures use a 0.2 to 1 bar (3 to 15 psig) output pressure range as an example. For a 0.4 to 2 bar (6 to 30 psig) output range, adjust the values as appropriate.

1. Complete the supply pressure connection and provide a process temperature equal to the sensing element range

2. Rotate the proportional band knob, shown in figure 7, to 1.5 (15 percent proportional band).

3. Verify that the calibration adjuster screws (key 43) are at mid-position in the calibration adjuster (key 41) slots.

Depending upon the controller action, perform one or the other of the following procedures.

For direct-acting controllers:

4. Place the temperature element bulb in the minimum temperature bath.

5. Rotate the temperature setting knob, to the temperature of the minimum temperature bath.

6. Adjust the nozzle (key 57) until the controller output pressure is between 0.6 and 0.7 bar (8 and 10 psig).

7. Place the temperature element bulb in the maximum temperature bath.

8. Rotate the temperature setting knob to the temperature of the maximum temperature bath.

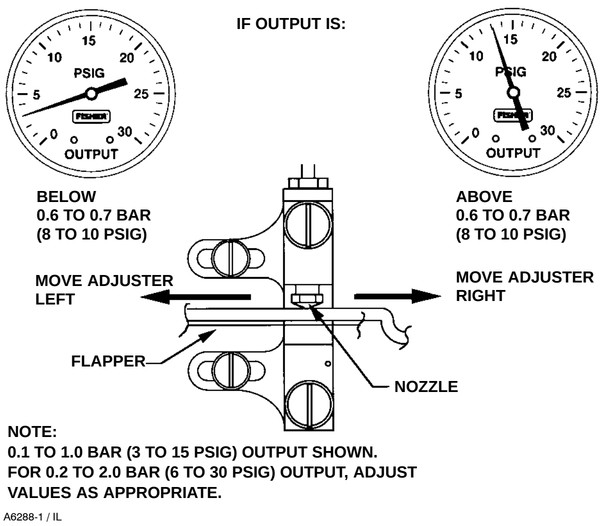


Figure 8. Direct-Acting Controller Span Adjustment — Proportional-Only Controllers

Note

When performing the span adjustment in step 9, do not watch the output gauge while changing the calibration adjuster. The change in output is not a good indication of a change in span. While moving the calibration adjuster, the output pressure may change in a direction opposite to that expected. For example, while moving the calibration adjuster to increase span, the output pressure may decrease. This should be disregarded since, even though the output pressure decreases, the span is increasing.

Proper controller response depends on nozzle-to-flapper alignment.

When performing span adjustments, carefully loosen both calibration adjuster screws while holding the calibration adjuster in place. Then move the calibration adjuster slightly in the required direction by hand or using a screwdriver. Verify proper nozzle-to-flapper alignment and hold the calibration adjuster in place while tightening both adjustment screws

9. If the output is not between 0.6 and 0.7 bar (8 and 10 psig), adjust the controller span by loosening one of the two adjusting screws (key 43) and move the calibration adjuster (key 41) a small distance as indicated in figure 8.

10. Repeat steps 4 through 9 until no further adjustment is necessary.

11. Proceed to the Startup: Proportional Only Controllers procedures in this section.

For reverse-acting controllers:

4. Place the temperature element bulb in the maximum temperature bath.

5. Rotate the temperature setting knob to the temperature of the maximum temperature bath.

6. Adjust the nozzle (key 57) until the controller output pressure is between 0.6 and 0.7 bar (8 and 10 psig).

7. Place the temperature element bulb in the minimum temperature bath.

8. Rotate the temperature setting knob, to the temperature of the minimum temperature bath.

Note

When performing the span adjustment in step 9, do not watch the output gauge while changing the calibration adjuster. The change in output is not a good indication of a change in span. While moving the calibration adjuster, the output pressure may change in a direction opposite to that expected. For example, while moving the calibration adjuster to increase span, the output pressure may decrease. This should be disregarded since, even though the output pressure decreases, the span is increasing.

Proper controller response depends on nozzle-to-flapper alignment.

When performing span adjustments, carefully loosen both calibration adjuster screws while holding the calibration adjuster in place. Then move the calibration adjuster slightly in the required direction by hand or using a screwdriver. Verify proper nozzle-to-flapper alignment and hold the calibration adjuster in place while tightening both adjustment screws

9. If the output is not between 0.6 and 0.7 bar (8 and 10 psig), adjust the controller span by loosening one of the two adjusting screws (key 43) and move the calibration adjuster (key 41) a small distance as indicated in figure 9.

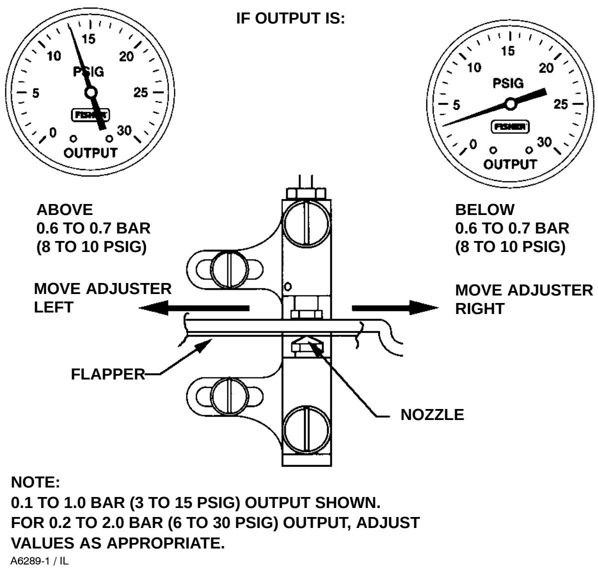


Figure 9. Reverse-Acting Controller Span Adjustment — Proportional-Only Controllers

10. Repeat steps 4 through 9 until no further adjustment is necessary.

11. Proceed to the Startup: Proportional Only Controllers procedures in this section.

Startup: Proportional-Only Controllers (General Tuning Guidelines)

If necessary, calibrate the controller prior to this procedure.

1. Be sure that the supply pressure regulator is delivering the proper supply pressure to the controller.

2. Rotate the temperature setting knob to the desired temperature.

3. Determine the initial proportional band setting (P.B.) in percent from the following equation:

$$\frac{200 \times \text{Allowable Overshoot}}{\text{Temperature Span}} = \text{P.B.}$$

For example:

$$\frac{200 \times 2^\circ}{30^\circ} \cong 13\%$$

1.3 proportional band setting

4. Proportional Action:

Disturb the system by tapping the flapper lightly or change the set point a small amount and check for system cycling. If the system does not cycle then lower the proportional band (raising the gain) and disturb the system again. Continue this procedure until the system cycles. At that point, double the proportional band setting.

Note

Proportional band adjustment affects the set point. Proportional-only controllers will show some offset from set point depending upon proportional band setting and process demand. After adjusting the proportional band, re-zero by carefully rotating the nozzle (key 57) until the steady-state process temperature equals the temperature setting knob reading.

This tuning procedure may be too conservative for some systems. The recommended proportional band setting should be checked for stability by introducing a disturbance and monitoring the process.

Proportional-Plus-Reset Controllers

This section describes the adjustments and procedures for calibration and startup. The adjustment locations are shown in figure 10 unless otherwise specified. All adjustments must be made with the cover open. When the adjustments and calibration procedures are complete, close and latch the cover.

To better understand the adjustments and overall operation of the controller, refer to the Principle of Operation section in this manual for proportional-plus-reset controllers. Refer also to the controller schematic diagram (figure 14).

Adjustments

Adjustment: Set Point

The temperature setting knob is constructed with a white triangular indicator that moves along the edge of the “TEMP SETTING” dial. The white triangle is attached to the black knob surrounding the dial. Turn the temperature setting knob clockwise to increase the temperature set point, or counterclockwise to decrease the set point.

Rotate the knob until the indicator points to the desired set point value. The process temperature gauge will reflect the desired temperature if the controller is calibrated correctly.

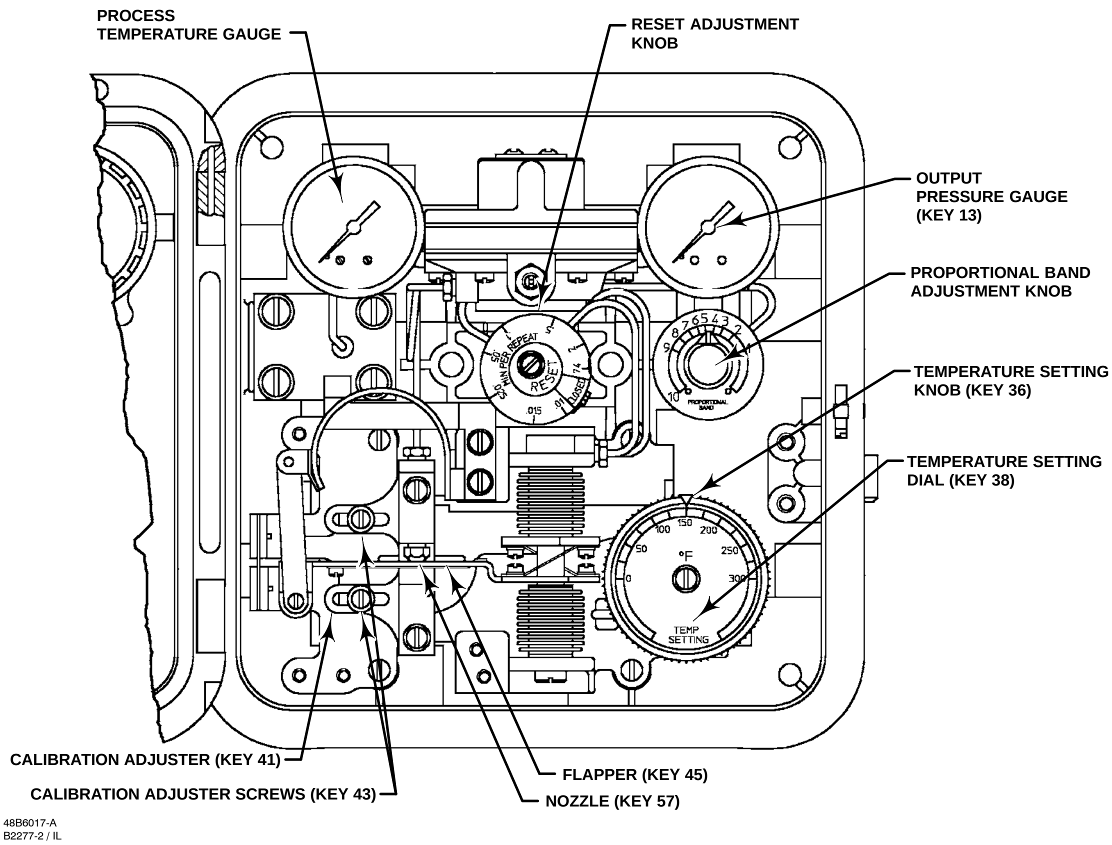


Figure 10. Location of Adjustment Proportional-Plus-Reset Controller

Adjustment: Proportional Band

Adjust the proportional band by rotating the proportional band knob to the desired value.

The proportional band adjustment determines the sensitivity (gain) of the controller, i.e., it determines the amount of change in process temperature required to change the controller output signal from one limit of the output range to the other limit. It may be adjusted from 6 to 200 percent of the nominal temperature bulb range for a 0.2 to 1 bar (3 to 15 psig) output signal, or 12 to 200 percent for a 0.4 to 2 bar (6 to 30 psig) output.

Adjustment: Reset

Adjust reset action by turning the knob clockwise to decrease the minutes per repeat. Turn the knob counterclockwise to increase the minutes per repeat. Increasing the minutes per repeat provides a slower reset action.

The reset adjustment dial is calibrated in minutes per repeat. By definition, this is the time in minutes required for the reset action to produce an output change which is equal to the change produced by proportional control action. This is in effect, the time in minutes required for the controller to increase (or decrease) its output pressure by an amount equal to a proportional increase (or decrease) caused by a change in set point or process temperature.

Adjustment: Anti-Reset Windup

This externally mounted differential relief valve (see figure 18) can be mounted to relieve on increasing or decreasing output pressure.

Calibration of Proportional-Plus-Reset Controllers

The controller is calibrated at the factory and should not need additional adjustment for most processes. Use the following calibration procedures when the sensing element has been changed or other maintenance procedures have altered the calibration of the controller. If you wish to use the factory calibration without using the following calibration procedure, proceed to the the Startup: Proportional-Plus-Reset Controllers (General Tuning Guidelines) subsection in this section.

WARNING

To avoid personal injury or property damage caused by the release of pressure or process fluid, observe the following before starting calibration:

- **Provide some temporary means of control for the process before taking the controller out of service.**
- **Vent any trapped process pressure from both sides of the control valve.**
- **Use lock-out procedures to be sure that the above measures stay in effect while you are working on the equipment.**
- **Check with your process or safety engineer for any additional measures that must be taken to protect against process media.**

Bench Calibration: Proportional-Plus-Reset Controllers

Unless otherwise indicated, key number and part locations are shown in figure 10.

Refer to the description of temperature baths at the start of the Controller Operation section. Provide a temperature source capable of simulating the process temperature range of the controller.

Note

If a maximum temperature bath with a temperature equal to the upper range limit of the temperature element bulb is not available, use any temperature that is available within the range. Then, adjust the set point to the temperature of the bath.

The controller must be connected open loop (Open loop: The controller output pressure changes must be dead ended into a pressure gauge). The following procedures use a 0.2 to 1.0 bar (3 to 15 psig) output pressure range as an example. For a 0.4 to 2 bar (6 to 30 psig) output range, adjust the values as appropriate.

Note

Type 4166KF (anti-reset windup) controllers are supplied with two O-rings (key 367, not shown), and anti-reset windup cover (key 369, not shown), and two machine screws (key 368, not shown). Use these parts in the next step.

1. For controllers with anti-reset windup (Type 4166KF), record the direction of the arrow on the anti-reset windup assembly (key 186, in figure 18). Remove the assembly and install the two O-rings, and cover supplied with the controller. Secure the cover with the two machine screws provided.

2. Connect regulated supply pressure to the controller. Do not exceed the normal operating pressure in table 3.

3. Rotate the reset knob to 0.01 minutes per repeat (fastest setting).

4. Rotate the proportional band knob to 1.5 (15 percent proportional band).

5. Verify that the calibration adjuster screws (key 43) are at mid-position in the calibration adjuster (key 41) slots.

Depending upon the controller action, perform one or the other of the following procedures.

For direct-acting controllers:

6. Place the temperature element bulb in the minimum temperature bath.

7. Rotate the temperature setting knob to the temperature of the minimum temperature bath.

8. Adjust the nozzle (key 57) until the controller output pressure is between 0.6 and 0.7 bar (8 and 10 psig).

9. Place the temperature bulb in the maximum temperature bath.

10. Rotate the temperature setting knob to the temperature of the maximum temperature bath.

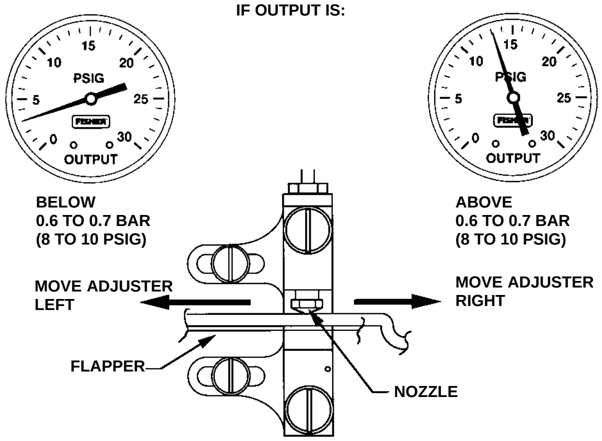


Figure 11. Direct-Acting Controller Span Adjustment — Proportional-Plus-Reset Controllers

Note

When performing the span adjustment in step 11, do not watch the output gauge while changing the calibration adjuster. The change in output is not a good indication of a change in span. While moving the calibration adjuster, the output pressure may change in a direction opposite to that expected. For example, while moving the calibration adjuster to increase span, the output pressure may decrease. This should be disregarded since, even though the output pressure decreases, the span is increasing.

Proper controller response depends on nozzle-to-flapper alignment.

When performing span adjustments, carefully loosen both calibration adjuster screws while holding the calibration adjuster in place. Then move the calibration adjuster slightly in the required direction by hand or using a screwdriver. Verify proper nozzle-to-flapper alignment and hold the calibration adjuster in place while tightening both adjustment screws

11. If the output is not between 0.6 and 0.7 bar (8 and 10 psig), adjust the controller span by loosening one of the two adjusting screws (key 43) and move the calibration adjuster (key 41) a small distance as indicated in figure 11.

12. Repeat steps 6 through 11 until no further adjustment is necessary.

13. For controllers with anti-reset windup (Type 4166KF), remove the two machine screws, anti-reset windup cover, and two O-rings installed in step 1 of this procedure. Install the anti-reset windup assembly (key 186, figure 18) with the arrow pointing in the direction recorded in step 1.

14. Proceed to the Startup: Proportional-Plus-Reset Controllers procedures in this section.

For reverse-acting controllers:

6. Place the temperature bulb in the maximum temperature bath.

7. Rotate the temperature setting knob to the temperature of the maximum temperature bath.

8. Adjust the nozzle (key 57) until the controller output pressure is between 0.6 and 0.7 bar (8 and 10 psig).

9. Place the temperature element bulb in the minimum temperature bath.

10. Rotate the temperature setting knob to the temperature of the minimum temperature bath.

Note

When performing the span adjustment in step 11, do not watch the output gauge while changing the calibration adjuster. The change in output is not a good indication of a change in span. While moving the calibration adjuster, the output pressure may change in a direction opposite to that expected. For example, while moving the calibration adjuster to increase span, the output pressure may decrease. This should be disregarded since, even though the output pressure decreases, the span is increasing.

Proper controller response depends on nozzle-to-flapper alignment.

When performing span adjustments, carefully loosen both calibration adjuster screws while holding the calibration adjuster in place. Then move the calibration adjuster slightly in the required direction by hand or using a screwdriver. Verify proper nozzle-to-flapper alignment and hold the calibration adjuster in place while tightening both adjustment screws

11. If the output is not between 0.6 and 0.7 bar (8 and 10 psig), adjust the controller span by loosening

one of the two adjusting screws (key 43) and move the calibration adjuster (key 41) a small distance as indicated in figure 12.

12. Repeat steps 6 through 11 until no further adjustment is necessary.

13. For controllers with anti-reset windup (Type 4166KF), remove the two machine screws, anti-reset windup cover, and two O-rings installed in step 1 of this procedure. Install the anti-reset windup assembly (key 186, figure 18) with the arrow pointing in the direction recorded in step 1.

14. Proceed to the Startup: Proportional-Plus-Reset Controllers procedures in this section.

Calibration: Anti-Reset Windup

Controllers with anti-reset windup have a differential relief valve assembly (figure 18). This relief valve is set at the factory to relieve at a 0.3 bar (5 psi) pressure difference between the reset bellows pressure and the proportional bellows pressure. The valve can be adjusted to relieve from 0.14 to 0.5 bar (2 to 7 psig).

The relief valve can relieve on either rising controller output pressure or falling controller output pressure. If the arrow on the relief valve points toward the bottom of the controller case as shown in figure 18, the valve will relieve on falling output pressure. If the arrow points in the opposite direction, the valve will relieve on rising output pressure. Remove the valve and reinstall it with the arrow pointing in the opposite direction to change the relief action.

Startup: Proportional-Plus-Reset Controllers (General Tuning Guidelines)

If necessary, calibrate the controller prior to this procedure.

1. Be sure that the supply pressure regulator is delivering the proper supply pressure to the controller.

2. Rotate the temperature setting knob to the desired temperature.

3. Start with a reset setting of 0.5 m/r.

4. Determine the initial proportional band setting (PB) in percent from the following equation.

$$\frac{200 \times \text{Allowable Overshoot}}{\text{Temperature Span}} = \text{P.B.}$$

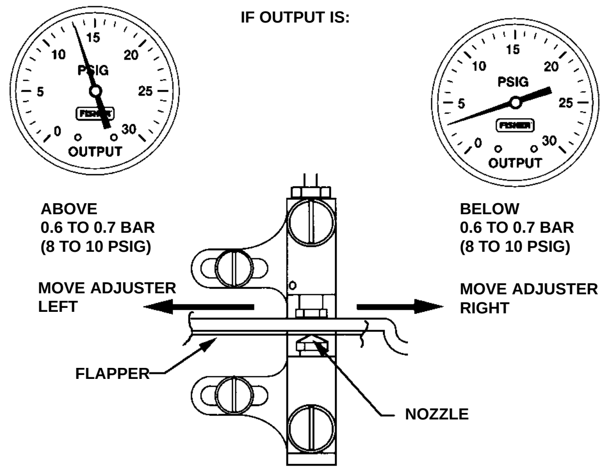


Figure 12. Reverse-Acting Controller Span Adjustment — Proportional-Plus-Reset Controllers

For Example:

$$\frac{200 \times 2^\circ}{30^\circ} \cong 13\%$$

1.3 proportional band setting

5. Proportional Action:

Disturb the system by tapping the flapper lightly or change the set point a small amount and check for system cycling. If the system does not cycle then lower the proportional band (raising the gain) and disturb the system again. Continue this procedure until the system cycles. At that point, double the proportional band setting and begin tuning the reset.

6. Reset Action:

Disturb the system. If the system does not cycle then speed up the reset and disturb the system again. Continue this procedure until the system cycles. When the system cycles multiply the reset time setting by a factor of three (3) and slow the reset down to the new value. The reset is now tuned.

This tuning procedure may be too conservative for some systems. The recommended proportional band and reset setting should be checked for stability by introducing a disturbance and monitoring the process as previously described. For some applications, tighter control may be desirable.

Differential Gap Controllers

This section describes the adjustments and procedures for calibration and startup. The

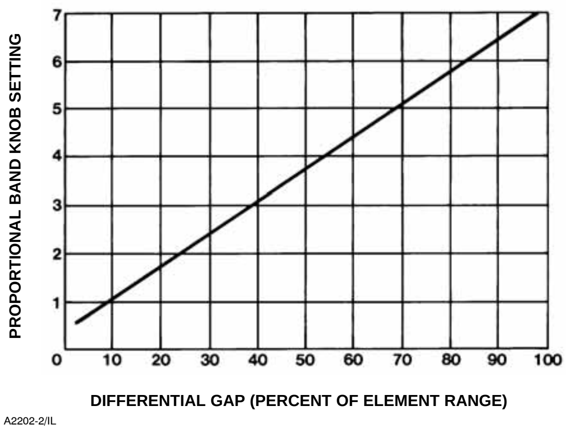


Figure 13. Relationship of Differential Gap and Proportional Band

adjustment locations are shown in figure 7 unless otherwise noted. The output of each controller is checked at the factory before the controller is shipped.

To convert a differential gap controller to a proportional-only controller or vice versa, refer to the appropriate procedure in the Maintenance section.

If the process temperature can be varied through all or part of the temperature element range or through the two desired switching points, use the process temperature for calibration. If not, provide appropriate temperature sources, such as temperature baths, to simulate the process temperature range for calibration procedures.

To better understand the adjustments and overall operation of the controller, refer to the Principle of Operation section in this manual.

Adjustments

Adjustment: Set Point

The position of the temperature setting knob determines the location of the differential gap within the range of the temperature sensing element. Move the pointer to the desired temperature where the output of the controller is to switch from zero to full supply pressure with rising process temperature (direct-acting controllers) or with falling process temperature (reverse-acting controllers).

Adjustment: Proportional Band

The proportional band adjustment shown in figure 7 determines the width of the differential gap. The width of the gap is the difference between the process temperatures at which the controller output will switch from zero to full supply pressure, or from full supply pressure to zero. The relationship between the proportional band knob setting and the differential gap is shown in figure 13.

Bench Calibration of Differential Gap Controllers

The controller is calibrated at the factory and should not need additional adjustment. If you wish to use the factory calibration without using the following calibration procedure, proceed to the Startup: Differential Gap Controllers (General Tuning Guidelines) subsection in this section. Use the following calibration procedures when the sensing element has been changed or other maintenance procedures have altered controller calibration.

Before placing the controller in control of a process loop, check to verify that the controller is calibrated correctly for the application. The controller must be connected open loop (Open loop: The controller output pressure changes must be dead ended into a pressure gauge).

Refer to the description of temperature baths at the start of the Controller Operation section. Provide a temperature source capable of simulating the process temperature range of the controller.

Note

If a maximum temperature bath with a temperature equal to the upper range limit of the temperature element bulb is not available, use any temperature that is available within the range. Then, adjust the set point to the temperature of the bath.

Unless otherwise indicated, key number locations are shown in figure 15.

1. Temporarily convert the differential gap controller to a proportional-only controller by disconnecting the proportional tubing (key 104, figure 17) from the mounting base. Reinstall the tubing into the other connection in the mounting base as shown in figure 15. Do not invert the reversing block (key 59, figure 19).

2. Perform the bench calibration procedures for proportional-only controllers

3. Upon completion of the calibration procedures, reinstall the tubing (key 104, figure 17) in its original

location. And, continue with the following procedures.

Note

After reinstalling the tubing (key 104) in step 3, a slight offset of the output pressure will be noticed due to switching from the proportional bellows to the reset bellows. This is because the effective area and spring rate of the two bellows may not match. Performing step 6b. below adjusts for this offset.

4. Refer to figure 13 to determine the proportional band dial setting required for the desired differential gap.

For example, assume that a −18 to 38°C (0 to 100°F) temperature bulb is being used and the direct-acting controller is to switch from zero to full supply pressure at a process temperature of 27°C (80°F) with rising process temperature and from full supply pressure to zero at –7°C (20°F) with falling process temperature (for a direct-acting controller). The differential gap is:

$$\frac{80^\circ F - 20^\circ F}{100^\circ F} \times 100 = 60\%$$

$$\frac{27^\circ C - 7^\circ C}{38^\circ C} \times 100 = 60\%$$

According to figure 13, the proportional band dial setting should be approximately 4.5; rotate the proportional band knob to 4.5.

5. Adjust the proportional band knob for the proper differential gap (see figure 7).

6. Setting the process temperature:

For direct-acting controllers:

a. Rotate the temperature setting knob to the temperature at which the controller output is to switch from zero to full supply pressure with rising process temperature. In the above example, this temperature is 27°C (80°F).

b. Increase the temperature at the temperature bulb while monitoring the output pressure gauge. The controller output pressure should switch from zero to full supply pressure as the upper switching point is reached with rising input temperature.

Note

If the upper switching point is not correct, adjust the nozzle to correct the error. Repeat step 6b. until the input temperature and upper switching point are at the desired setting.

c. With falling input temperature, the output should switch from full supply pressure back to zero as the lower switching point is reached.

Reverse-acting controllers produce the opposite response.

7. Vary the process temperature by switching the temperature from the maximum temperature bath to the minimum temperature bath. Observe the switching points. If necessary, widen or narrow the differential gap by rotating the proportional band knob, then repeat the above steps.

If the output is within the limits stated, refer to the startup procedures in this section. If the output pressure cannot be adjusted within the limits stated, refer to the maintenance procedures.

Startup: Differential Gap Controllers (General Tuning Guidelines)

If necessary, calibrate the controller prior to this procedure.

1. Be sure that the supply pressure regulator is delivering the proper supply pressure to the controller.

2. Adjust the proportional band knob for the proper differential gap (see figure 7).

3. If the controller is used in conjunction with a control valve, slowly open the upstream and downstream manual shutoff valves, and close the bypass valves.

4. To change the differential gap, perform steps 1 through 5 of the bench calibration of differential gap controllers procedure.

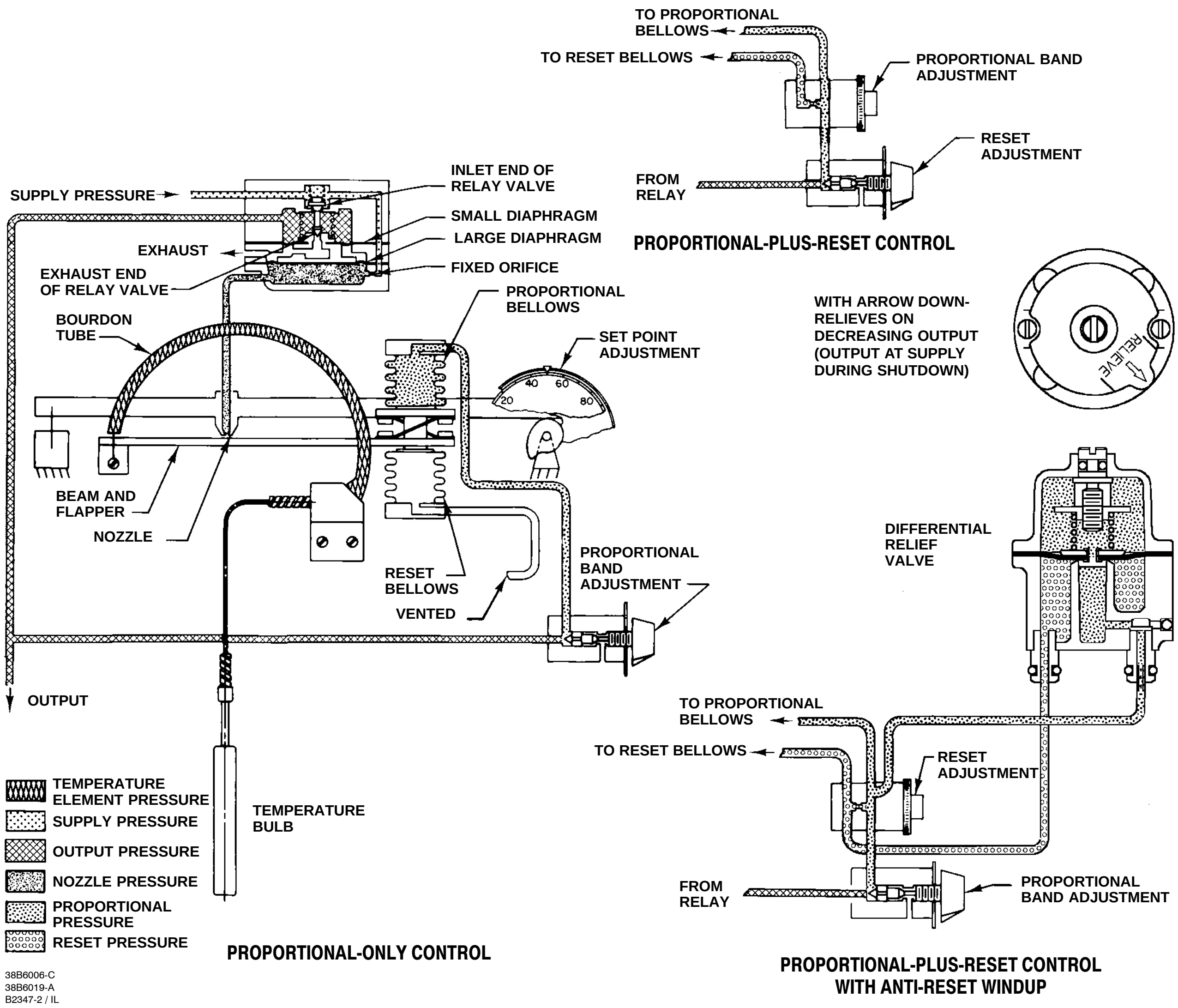


Figure 14. Schematics of Direct-Acting Proportional-Only and Proportional-Plus-Reset Controllers

Principle of Operation

This section describes the principles of operation for the Types 4156K and 4166K. To better understand the adjustments and overall operation of the controller, refer to figure 14 for an operational schematic.

Temperature Element Assembly

All the Wizard II temperature controllers accept, as an input, the process temperature, which is sensed by a temperature bulb immersed in the process fluid. The temperature bulb, a capillary tube, a Bourdon tube, and a temperature gauge calibrated for the appropriate temperature range form a closed system referred to as the temperature element assembly. The capillary tube connects the temperature bulb to the Bourdon tube and the temperature gauge, which are inside the controller case. As the sensed temperature varies, pressure inside the Bourdon tube varies proportionally. Because the volume of the temperature bulb is much larger than the volume of the capillary tube, temperature errors caused by the ambient temperature of the capillary tube are negligible.

Proportional Controllers

As shown in figure 14, supply pressure enters the relay and bleeds through the fixed orifice before escaping through the nozzle. Nozzle pressure also registers on the large relay diaphragm, and loading pressure (controller output pressure) registers on the small relay diaphragm.

As the temperature increases, pressure increases within the Bourdon tube extending its radius of arc. The flapper moves toward the nozzle (in a direct-acting controller) restricting flow through the nozzle and thus nozzle pressure increases. The increasing nozzle pressure acts on the large relay diaphragm which opens the inlet end of the relay valve. When this occurs, supply pressure increases the output pressure of the controller.

A portion of the output pressure is fed back to the proportional bellows, depending on the proportional band setting. The action of the proportional bellows counteracts the flapper movement that resulted from the process temperature change and backs the flapper away from the nozzle until equilibrium is attained.

A decreasing process temperature decreases nozzle pressure in a direct-acting controller as the Bourdon tube retracts and moves the flapper away from the nozzle. The decreasing nozzle pressure on the large relay diaphragm causes the relay valve to open the exhaust port. This exhausts the controller output which, in turn, reduces the controller output pressure.

The set point adjustment changes the proximity of the nozzle and flapper as does a change in process temperature. When the set point is changed, however, the nozzle moves with respect to the flapper. The proportional band adjustment varies the amount of output pressure that is fed back to the proportional bellows, changing the gain of the controller.

Controller action is changed from direct to reverse, and vice versa, by moving the reversing block and bellows connection as shown in figure 15. With the controller in the reverse-acting mode, an increase in process temperature causes a decrease in output pressure.

Proportional-Plus-Reset Controllers

Action of a proportional-plus-reset controller is similar to that of a proportional controller except that feedback from the controller output pressure is piped to a reset bellows as well as to the proportional bellows as shown in figure 14.

Supply pressure is connected to the pressure-balanced relay, with its double diaphragm assembly, and bleeds through the fixed orifice before escaping through the nozzle. The nozzle pressure registers on the large relay diaphragm and the loading pressure (controller output pressure) registers on the small relay diaphragm.

As the process temperature increases, pressure increases within the Bourdon tube extending its radius of arc. The flapper moves toward the nozzle (in a direct-acting controller) restricting flow through the nozzle and thus nozzle pressure increases. The increasing nozzle pressure acts on the large relay input diaphragm, which moves the diaphragm head assembly down, opening up the supply valve. This allows supply pressure to flow into the relay output chamber.

A portion of the output pressure is fed back to the proportional bellows. The amount of feedback depends on the proportional band setting. The action of the proportional bellows counteracts the flapper movement that resulted from the process temperature change and backs the flapper away from the nozzle.

Pressure to the reset bellows must first pass through the reset valve, causing a time delay. Once the pressure reaches the reset bellows, it opposes the proportional bellows and moves the flapper, starting another pressure change throughout the system. The change continues until the process temperature is returned to set point and the pressures in the two bellows are once again equal. The reset control is calibrated with open loop conditions in minutes per repeat, which is the time in minutes required for reset action to cause an output pressure change equal to the initial output pressure change caused by proportional action.

A decreasing process temperature decreases nozzle pressure in a direct-acting controller as the Bourdon tube retracts and moves the flapper away from the nozzle. The decreasing nozzle pressure on the large diaphragm causes the relay valve to open the exhaust port. This exhausts the controller output, which starts to close the supply valve, reducing the controller output pressure. The proportional and reset actions then react to the change in output pressure in a manner similar to that described above.

The set point adjustment changes the proximity of the nozzle and flapper as does a change in process temperature. When the set point is changed, however, the nozzle moves with respect to the flapper. The proportional band adjustment varies the amount of output pressure that is fed back to the proportional bellows, changing the gain of the controller.

Controller action is changed from direct to reverse, and vice versa, by moving the reversing block and bellows connection as shown in figure 15. With the controller in the reverse-acting mode, an increase in process temperature causes a decrease in output pressure.

Controllers with Anti-Reset Windup

The Type 4166KF controller is a proportional-plus-reset controller with an external differential relief valve (see figure 18) to provide anti-reset windup. With this valve set to relieve on decreasing output pressure, as shown in figure 14, proportional pressure registers rapidly on the spring side of the relief valve diaphragm as well as in the proportional bellows. The reset pressure registers on the opposite side of the relief valve diaphragm.

As long as temperature changes are slow enough for normal proportional and reset action, the relief valve spring prevents opening of the relief valve diaphragm. However, a large or rapid increase in process temperature causes the relay to exhaust loading pressure rapidly from the control device, and also from the proportional system and spring side of the relief diaphragm. If this decrease on the spring side of the diaphragm is greater than the relief valve spring setting, the diaphragm moves off the relief valve orifice and permits the reset pressure on the opposite side of the relief valve diaphragm to bleed rapidly into the proportional system.

The action can be reversed to relieve on increasing output pressure. If the arrow on the differential relief valve (see figure 18) points to the bottom of the controller, the valve relieves with decreasing output pressure. If the arrow points to the top of the controller, the valve relieves with increasing output pressure. Anti-reset windup reduces process temperature overshoot that can result from a large or prolonged deviation from set point.

Differential-Gap Controllers

With a differential-gap controller, feedback pressure does not counteract the change in flapper position as it does in a proportional controller. Instead, feedback pressure is piped through the proportional valve to the bellows located on the side of the beam and flapper opposite the nozzle (the lower bellows in figure 14 for direct acting-controllers). Then, as controller output pressure increases, feedback pressure moves the flapper closer to the nozzle to again increase controller output pressure. This process continues rapidly until controller output pressure is at the upper range limit of the range. The action of a differential-gap controller is so rapid that output pressure changes from zero to maximum as soon as the switching point is reached. The action is similar with falling output pressure. Lower feedback pressure lowers the bellows pressure, which moves the flapper away from the nozzle. This again reduces output pressure and continues until output pressure is zero.

Supply pressure is connected to the pressure-balanced relay, with its double diaphragm assembly, and bleeds through the fixed orifice before escaping through the nozzle. The nozzle pressure registers on the large relay diaphragm and the loading pressure (controller output pressure) registers on the small relay diaphragm.

As the process temperature increases, pressure increases within the Bourdon tube, extending its radius of arc. Thus, the flapper moves toward the nozzle (in a direct-acting controller). It restricts flow through the nozzle and nozzle pressure increases. The increasing nozzle pressure registers on the large relay input diaphragm and when the high trip point is reached, the diaphragm head assembly moves down, opening up the supply valve. This allows supply pressure to flow into the relay output chamber. The output pressure is fed back to the positive feedback bellows, moving the flapper even closer to the nozzle and rapidly in- creasing the output pressure to the upper range limit.

As the process temperature decreases towards the low trip point, nozzle pressure decreases because the flapper moves away from the nozzle. At the low trip point the relay valve opens the exhaust port. This causes a falling output pressure which reduces the bellows pressure, moving the flapper away from the nozzle and decreasing the output pressure rapidly to zero. The difference between the process temperature when the controller output switches to zero and the process temperature when the controller output switches to maximum is the differential gap. The width of the gap is adjustable with the proportional band adjustment; the position of the gap within the temperature element range is adjustable with the set point adjustment.

Maintenance

This section describes a variety of regular maintenance procedures including: filter-regulator maintenance, replacement of the temperature element, replacement of the proportional, reset, or differential relief valve, and replacement of the relay. It also describes how to change the controller action and the controller output signal range.

Preventative Maintenance Procedures

If the installation includes a 67 Series filter-regulator, periodically open the drain on the filter-regulator to drain accumulated moisture. Establish a maintenance cycle for the filter and regulator to ensure that they are clean and functioning properly. Clean the opening of the vent assembly (key 15, figure 17 or 18) regularly as necessary to keep it from becoming plugged. The relay orifice (key 88, not shown) can be cleaned by pressing the cleaner wire (key 89, not shown).

Parts are subject to normal wear and must be inspected and replaced as necessary. The frequency of inspection and parts replacement depends upon the severity of the service conditions.

WARNING

To avoid personal injury or property damage caused by the release of pressure or process fluid, observe the following before starting maintenance:

- **Always wear protective clothing, gloves, and eyewear when performing any maintenance procedures to avoid personal injury.**
- **Provide some temporary means of control for the process before taking the controller out of service**
- **Provide a means of containing the process fluid before removing the temperature bulb from the process**
- **Vent any trapped process pressure from both sides of the control valve.**
- **Use lock-out procedures to be sure that the above measures stay in effect while you are working on the equipment.**
- **Personal injury or property damage may result from fire or explosion if natural gas is used as the supply medium and preventative measures are not taken. Preventative measures may include: Remote venting of the unit, re-evaluating the hazardous area classification, ensuring adequate ventilation, and the removal of any ignition sources. For information on remote venting of this controller, refer to page 8.**
- **Check with your process or safety engineer for any additional measures that must be taken to protect against process media.**

Replacing the Temperature Element

WARNING

Refer to the WARNING at the beginning of the Maintenance Section.

Unless noted otherwise, key numbers refer to figure 19.

Removal

1. Shut off the supply pressure to the controller, and remove the temperature bulb from the process.

2. Remove the machine screws and washers (keys 77 and 76 and keys 82 and 101, figure 17 or 18). Remove the machine screw (key 63) that holds the connecting link (key 64) in place; take care not to lose the link bearing (key 65).

3. Lift the Bourdon tube and process temperature gauge (these are part of the temperature element assembly) away from the case, withdrawing the capillary tube and temperature bulb through the opening in the rear of the case.

Installation

1. Install the temperature element assembly (key 78, figure 20) by feeding the temperature bulb and capillary tube through the opening at the rear of the case.

2. Attach the link and bearing to the Bourdon tube.

3. Position the Bourdon tube and process temperature gauge, and install and tighten the machine screws and washers (keys 77 and 76 and keys 82 and 101, figure 17 or 18).

4. Connect the link and bearing to the beam.

5. After connecting the link to the beam, make sure the nozzle is centered in the slot in the beam. If not, carefully loosen the machine screw (key 63) enough so that you can slip a washer (key 370) between the bearing (key 65) and beam (key 44). Retighten the machine screw and check the nozzle and beam alignment.

6. Check to be sure that the beam is parallel with the bottom of the case and that the link (key 64) is in tension. If the beam is not parallel with the case, loosen the machine screws (key 77), reposition the Bourdon tube to get the beam parallel, and retighten the screws.

7. Perform the appropriate calibration procedure.

Changing the Proportional or Reset Valve

1. Disconnect the appropriate tubing and remove the proportional band adjustment valve assembly (figure 17) or the reset adjustment valve assembly (key 256, figure 18) by unscrewing it from the case. Install the desired replacement assembly.

2. Connect the tubing and check all connections for leaks and perform the appropriate calibration procedure.

Changing the Anti-Reset Windup Differential Relief Valve (4166KF)

Refer to figure 18 for key number locations.

1. Note the controller output pressure (zero or supply) when the process is shut down.

2. Remove the differential relief valve assembly.

3. Refer to figure 18. Install the replacement relief valve with the arrow positioned so that the controller output will be as noted in step 1 when the process is shut down.

Changing Action

⚠ WARNING

Refer to the WARNING at the beginning of the Maintenance Section.

Proportional-Only to a Differential Gap Controller

It is possible to change a proportional-only controller to a differential gap controller, or vice versa, by changing the position of the proportional tubing (key 104, figure 15).

1. Isolate the controller from supply pressure. Vent any trapped pressure from the controller before proceeding with the following steps.

2. Disconnect the proportional tubing (key 104) from the mounting base (key 30, figure 19) and reinstall it in the other connection in the mounting base.

3. Do not invert the reversing block unless also changing the controller action.

4. Check all connections for leaks with a soap-and-water solution. Perform the appropriate calibration procedure.

Direct to Reverse Action

Use the numbered steps below to change from direct action (increasing temperature produces increasing output pressure) to reverse action (increasing temperature produces decreasing output pressure), or vice versa. Changing the action is accomplished by reversing the positions of the reversing block and bellows tubing(s).

Key numbers are shown in figure 15 unless otherwise noted.

1. Isolate the controller from supply pressure. Vent any trapped pressure from the controller before proceeding with the following steps.

2. Locate the new tubing and reversing block positions for the action desired.

3. Locate the two bellows and the reversing block (key 59).

4. Disconnect tubing:

   a. **For a proportional-only controller**, disconnect the proportional tubing (key 104) from the mounting base (key 30, figure 19) and reconnect it in the opposite hole.

   b. **For a proportional-plus-reset controller**, disconnect the proportional tubing (key 104) from the mounting base (key 30, figure 19) and disconnect the reset tubing (key 117) from the mounting base, and reconnect it in the opposite hole.

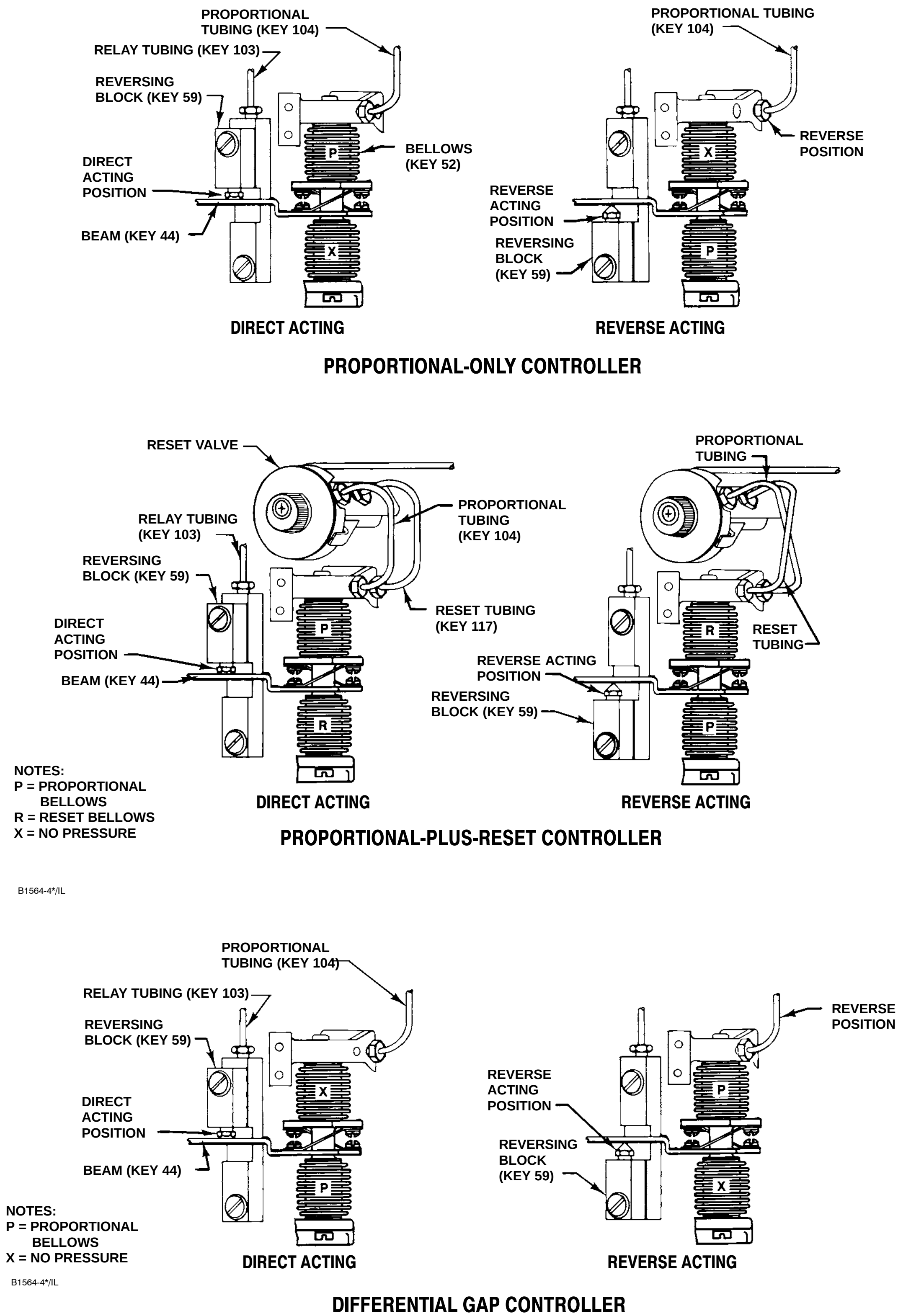


Figure 15. Direct/Reverse Acting Tubing Connections

5. Change the reversing block assembly (key 59):

a. Remove the sealing screw (key 56). Inspect the O-ring (key 55) located in the recessed area under the sealing screw head. Replace the O-ring if necessary.

b. Remove the reversing block screw (key 61) and reversing block assembly (key 59). Inspect the O-rings (key 55) located in the recessed area under the reversing block screw head and between the reversing block assembly and the calibration adjuster (key 41). Replace these O-rings, if necessary.

c. Position the reversing block assembly, with O-ring, on the calibration adjuster (key 41) so that the nozzle is on the opposite side of the beam (key 44) from which it was removed. Properly position the reversing block assembly so that the alignment pin engages the hole in the calibration adjuster. Install the reversing block screw (key 61) with O-ring (key 55).

d. Install the sealing screw (key 56) with O-ring in the hole previously covered by the reversing block assembly.

6. Install the relay tubing (key 103) in the reversing block (key 59).

7. Check all connections for leaks with a soap-and-water solution. Perform the appropriate bench calibration procedures.

Relay Replacement

WARNING

Refer to the WARNING at the beginning of the Maintenance Section.

Key numbers are shown in figure 17 or 18 unless otherwise noted.

1. Isolate the controller from supply pressure. Vent any trapped pressure from the controller before proceeding with the following steps.

2. Disconnect the tubing (key 103) from the relay.

3. Unscrew the output gauge (key 13).

4. To remove the relay assembly, unscrew two Phillips-head machine screws (key 81, not shown) located behind the relay on the back of the case.

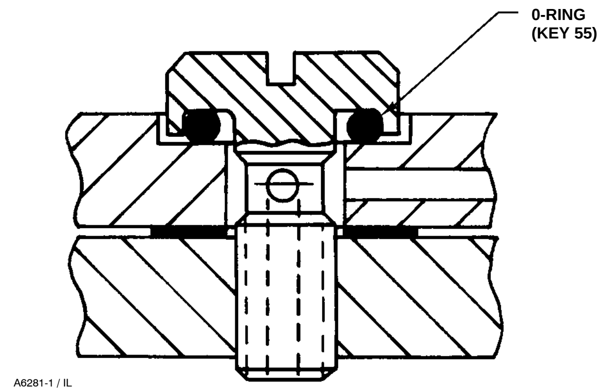


Figure 16. Bellows Screw Detail

5. Remove the relay gasket (key 7).

6. Attach the replacement relay and the new relay gasket with machine screws inserted through the back of the case. Reinstall the output gauge.

7. Check all air-tight connections for leaks with a soap and water solution, and tighten connections if necessary, prior to calibration.

8. Perform the appropriate calibration procedure.

Changing Output Signal Range

WARNING

Refer to the WARNING at the beginning of the Maintenance Section.

Use the following information and subsequent procedures when changing the output signal range of the controller. Use the following procedure:

- **For all controllers except differential gap**, use this procedure to change from a 0.2 to 1.0 bar (3 to 15 psig) to a 0.4 to 2.0 bar (6 to 30 psig) output signal range or vice versa.

- **For differential gap controllers**, use this procedure to change from a 0 and 1.0 bar (0 and 20 psig) to a 0 and 2.4 bar (0 and 35 psig) output signal range or vice versa.

- When changing the supply pressure source to a new range, refer to table 3 for supply pressure requirements for the output signal range selected.

Also, make appropriate changes to the nameplate (key 22, figure 17 or 18) of the controller reflecting the new range selections.

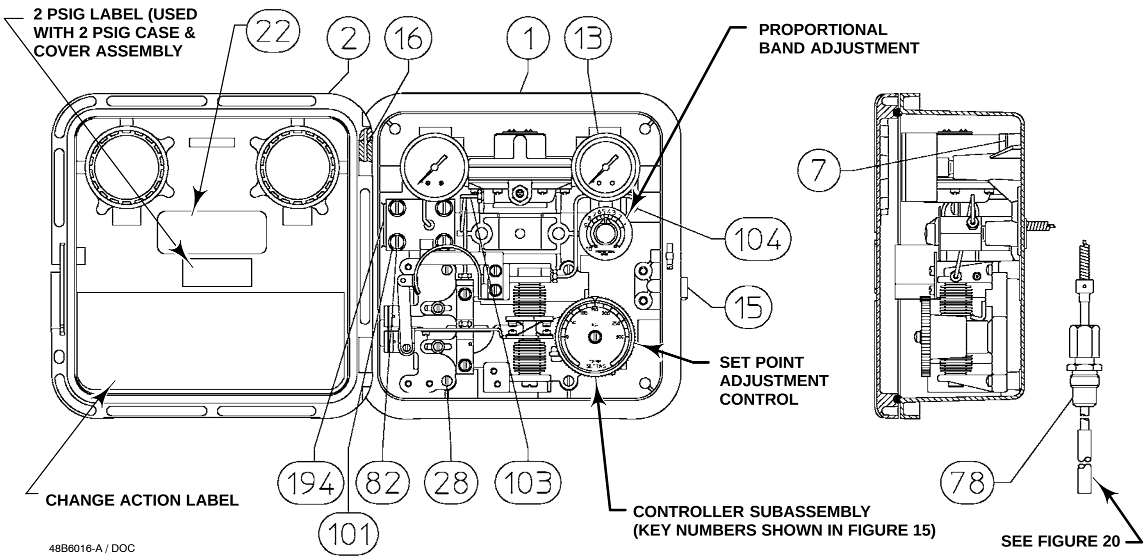


Figure 17. Proportional-Only Controller Assembly

Key numbers are shown in figure 19 unless otherwise noted.

1. Shut off the supply pressure to the controller. Remove the temperature bulb (part of the temperature element assembly key 78) from the process.

2. Open the cover. Disconnect the tubing from the mounting base (key 30) and calibration adjuster (key 41). Remove the machine screws and washers (keys 77 and 76 and keys 82 and 101, figure 17 or 18). Remove the machine screw (key 63) that holds the connecting link (key 64) in place; take care not to lose the link bearing (key 65). Lift the Bourdon tube and process temperature gauge (these are part of the temperature element assembly, key 78) away from the case, withdrawing the capillary tube and temperature bulb through the opening in the rear of the case.

3. Unscrew the machine screws (key 28, figure 17 or 18), and remove the subassembly from the case.

4. Unscrew the bellows screw (key 54) from each end of the mounting base (key 30). [Note: The bellows screws (key 54) have an O-ring (key 55, figure 16) installed beneath the bellows screw head. Remove the O-ring and obtain a replacement when re-assembling the bellows.]

5. Compress the bellows so that the end of the bellows and beam can be removed from the end of the mounting base (key 30) and unscrewed from the stud (key 51, not shown) that connects the bellows.

6. With the stud that connects the two bellows in place in the spacer (key 50), screw the new bellows onto the stud. Install new gaskets (key 53) on each bellows.

7. Compress the bellows, and install them into the mounting base (key 30). With the beam parallel with the mounting base, secure the bellows with the bellows screws (key 54).

Note

The bellows screws (key 54) have an O-ring (key 55) installed beneath the bellows screw head as shown in figure 16. Be sure this O-ring is in place before installing the screw into the mounting base.

8. After tightening the bellows screws, make sure that the nozzle (key 57) is centered on the flapper (key 45).

9. Replace the temperature element assembly (see figure 20) by referring to the Replacing the Temperature Element subsection within this Maintenance section.

10. Unscrew the output gauge (key 13, figure 17 or 18), and install a new gauge with the correct pressure ranges.

11. Check all tubing connections and the bellows machine screws for leaks, tighten as necessary, and perform the appropriate calibration procedure.

Parts Ordering

Whenever you correspond with your Emerson Process Management sales office about this equipment, mention the serial number found on the nameplate (key 22, figure 17 or 18) of the unit. When ordering replacement parts, state the complete 11-character part number of each part required as found in the following parts list.

WARNING

Use only genuine Fisher replacement parts. Components that are not supplied by Emerson Process Management should not, under any circumstances, be used in any Fisher instrument. Use of components not supplied by Emerson Process Management will void your warranty, might adversely affect the performance of the instrument, and could cause personal injury and property damage.

Note

Neither Emerson, Emerson Process Management, nor any of their affiliated entities assumes responsibility for the selection, use, or maintenance of any product. Responsibility for the selection, use, and maintenance of any product remains with the purchaser and end-user.

Parts Kits

Description	Part Number
Controller Repair Kits	
Kit contains Gasket (qty 2), Bellows Frame Gasket, Relay Gasket, Cover Gasket, O-ring, and keys 10, 45, 46, 53, 56, 57, 58, 59, 60, 61, 63, 64, 65 and 370	R4150X00L22
Relay Replacement Kits	
Kit Contains keys 7 & 81 and the relay assembly	
Standard Replacement Relay	RRELAYX0L22

Parts List

Subassemblies

Description	Part Number
Controller Subassembly (figure 19)	
(includes keys 30-35 and 41-61)	
4156K and 4156KS Controllers	
Brass Bellows	
0.2 to 1.0 bar (3 to 15 psig)	26A7681X012
0.4 to 2.0 bar (6 to 30 psig)	26A7681X032
Stainless Steel Bellows	
0.2 to 1.0 bar (3 to 15 psig)	26A7681X022
0.4 to 2.0 bar (6 to 30 psig)	26A7681X042
4166K and 4166KF Controllers	
Brass Bellows	
0.2 to 1.0 bar (3 to 15 psig)	26A7681X052
0.4 to 2.0 bar (6 to 30 psig)	26A7681X072
Stainless Steel Bellows	
0.2 to 1.0 bar (3 to 15 psig)	26A7681X062
0.4 to 2.0 bar (6 to 30 psig)	26A7681X082
Proportional Band Adjustment Assembly (figures 17 and 18)	
Type 4156K and 4156KS Controllers	10A9122X122
Type 4166K and 4166KF Controllers	10A9122X092

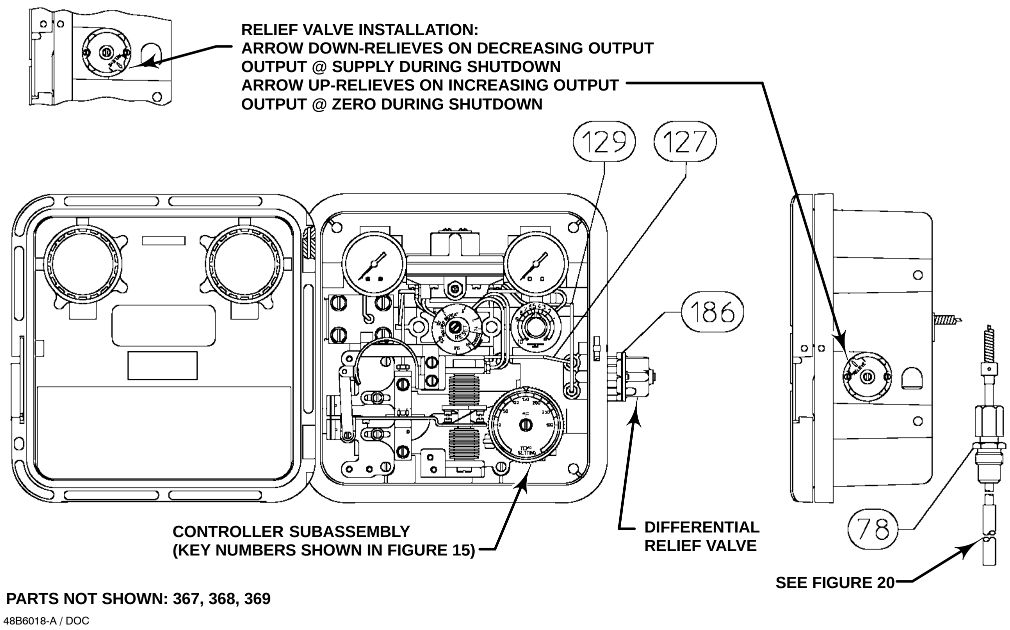
Controller and Controller Subassembly (figures 17, 18, and 19)

Note

Part numbers are shown for recommended spares only. For part numbers not shown, contact your Emerson Process Management sales office.

Key	Description	Part Number
1	Case and Cover Assembly, Aluminum	
7*	Relay Gasket(1), chloroprene	1C897403012
10*	Gasket(2), chloroprene	1C328603012
13*	Output Gauge	
	Dual Scale	
	0 to 30 psig/0 to 2 kg/cm^2	11B8577X042
	0 to 60 psig/0 to 4 kg/cm^2	11B8577X052
	Triple Scale	
	0 to 30 psig/0 to .2 MPa/0 to 2 bar	11B8577X012
	0 to 60 psig/0 to .4 MPa/0 to 4 bar	11B8577X022
14*	Supply Gauge (use w/67FR regulator)	
	Triple Scale	
	0 to 30 psig/0 to .2 MPa/0 to 2 bar	11B8579X022
	0 to 60 psig/0 to .4 MPa/0 to 4 bar	11B8579X032

*Recommended spare parts
1. This part is included in the Relay Replacement Kit
2. This part is included in the Controller Repair Kit



WITH DIFFERENTIAL RELIEF VALVE FOR ANTI-RESET WINDUP

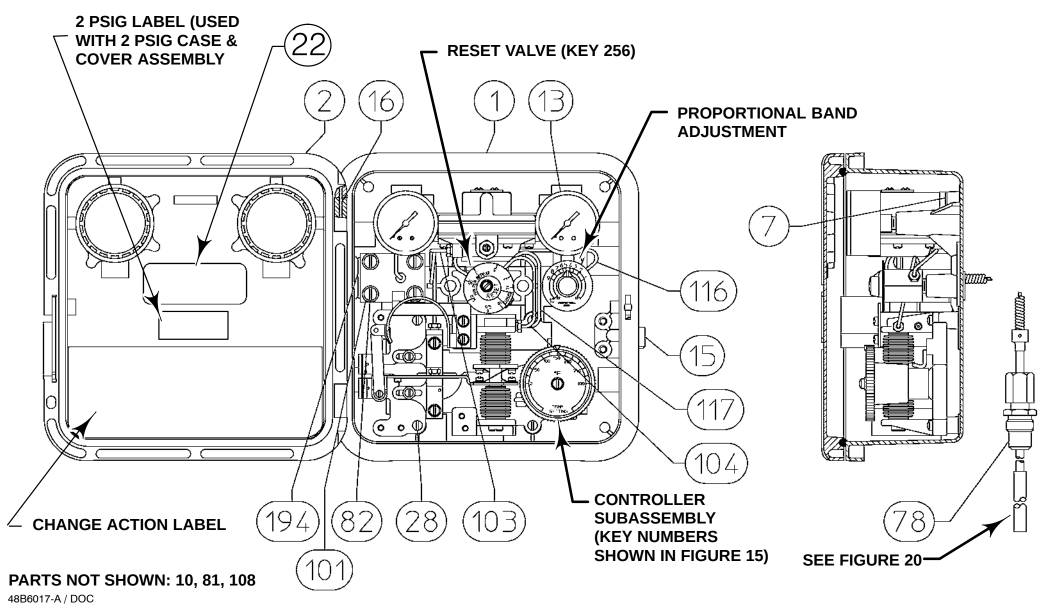


Figure 18. Proportional-Plus-Reset Controller Assembly

4156K and 4166K Controllers

Key	Description	Part Number
15	Vent Assembly	
16	Roll Pin, stainless steel (2 req'd)	
22	Instruction Plate, aluminum	
28	Machine Screw, pl steel (4 req'd)	

Note

Keys 30 through 35 are included in the controller subassemblies found on page 30 of this manual.

Key	Description	Part Number
30	Mounting Base, aluminum	
31	Flexure Strip, stainless steel	
32	Flexure Strip Washer, pl steel (2 req'd)	
33	Machine Screw, pl steel (4 req'd)	
34	Pressure Set Arm, pl steel	
35	Rotary Spring, stainless steel	
36	Knob, PPS	
37	Knob Spring, pl steel	
38	Dial, aluminum	
	Celsius temperature ranges	
	0 to 100	
	0 to 150	
	0 to 200	
	0 to 250	
	0 to 300	
	0 to 400	
	0 to 500	
	Fahrenheit temperature ranges	
	0 to 100	
	50 to 150	
	100 to 200	
	50 to 200	
	0 to 200	
	50 to 250	
	100 to 300	
	200 to 400	
	0 to 300	
	0 to 400	
	0 to 600	
	0 to 800	
	0 to 1000	
39	Washer, pl steel	
40	Machine Screw, pl steel	

Note

Keys 41 through 62 are included in the controller subassemblies found on page 30 of this manual.

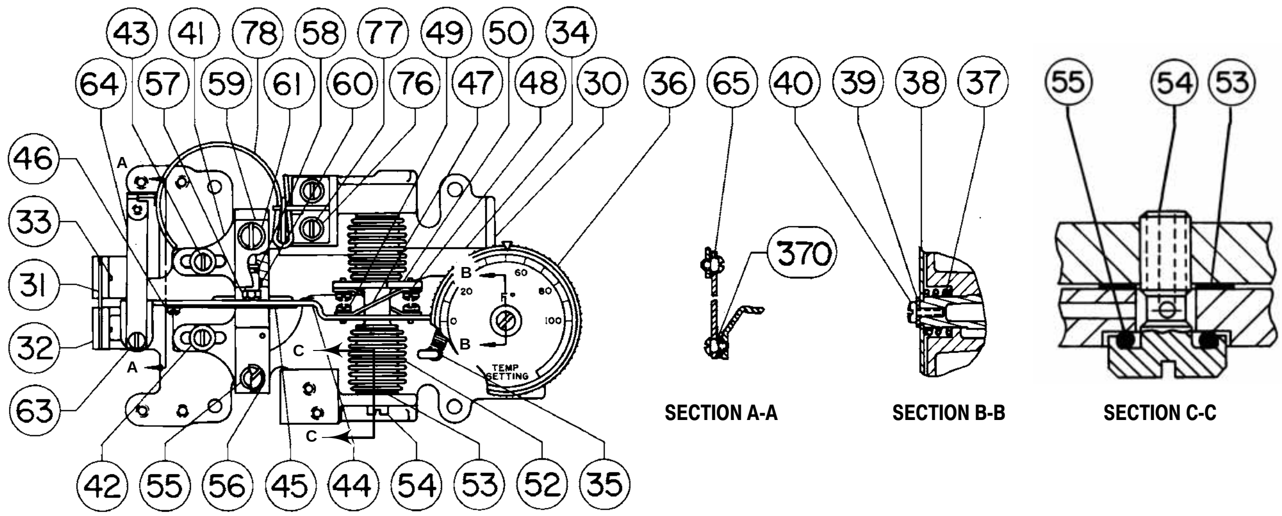
Key	Description	Part Number
41	Calibration Adjustor, zinc	
42	Washer, steel (2 req'd)	
43	Machine Screw, pl steel (2 req'd)	
44	Beam, pl steel	
45	Flapper(2), K93602 nickel alloy	
46	Machine Screw(2), pl steel	
47	Cross Spring, stainless steel (2 req'd)	
48	Washer, pl steel (4 req'd)	
49	Machine Screw, pl steel (4 req'd)	
50	Spacer, zinc	
51	Bellows Stud, brass (not shown)	
52*	Bellows Assembly (2 req'd)	
	Types 4156K & 4156KS	
	Brass	
	0.2 to 1.0 ba (r3 to 15 psig)	14A5726X012
	0.4 to 2.0 bar (6 to 30 psig)	14A5726X032
	Stainless steel	
	0.2 to 1.0 bar (3 to 15 psig)	14A5726X022
	0.4 to 2.0 bar (6 to 30 psig)	14A5726X042
	Types 4166K & 4166KF	
	Brass	
	0.2 to 1.0 bar (3 to 15 psig)	14A5725X012
	0.4 to 2.0 bar (6 to 30 psig)	14A5726X012
	Stainless steel	
	0.2 to 1.0 bar (3 to 15 psig)	14A5725X022
	0.4 to 2.0 bar (6 to 30 psig)	14A5726X022
53*	Gasket(2), chloroprene (2 req'd)	1D397003012
54	Bellows Screw, (2 req'd)	

Note

A total of 5 O-rings (key 55) are used. 1 O-ring is used under the sealing screw (key 56), 1 O-ring is used under the reversing block screw (key 61), 1 O-ring is used between the reversing block ass'y (key 59) and the calibration adjustor (key 41), and 1 O-ring is used in the recessed area under the head of each of the bellows screws (key 54).

Key	Description	Part Number
55*	O-Ring, nitrile (5 req'd)	1D687506992
56	Sealing Screw(2), 416 stainless steel	
57*	Nozzle(2), 416 stainless steel	1U639135132
58*	O-Ring(2), nitrile	1E222606992
59	Reversing Block(2), zinc	
60	Sleeve(2), POM	
61	Reversing Block Screw(2), 416 stainless steel	
63	Machine Screw(2), pl steel (2 req'd)	
64	Connecting Link(2), stainless steel	
65*	Link Bearing(2), heat treated 416 stainless steel (2 req'd)	1L379546202
76	Washer, pl steel (2 req'd)	
77	Machine Screw, pl steel (2 req'd)	
78	Temperature Element Temperature element details are shown in figures 5 and 20, and are only available as an assembly	
81	Machine Screw(1), pl steel (2 req'd) (not shown)	
82	Machine Screw, pl steel (4 req'd)	
101	Lockwasher, pl steel (4 req'd)	
103*	Relay Tubing Assembly, stainless steel	1H6861000A2

*Recommended spare parts
1. This part is included in the Relay Replacement Kit
2. This part is included in the Controller Repair Kit



26A7681-B/DOC

Figure 19. Controller Subassembly

Key	Description	Part Number
104*	Proportional Tubing Assembly, stainless steel	
	Type 4156K & 4156KS	1H6864000A2
	Type 4166K & 4166KF	1H6870000A2
108	Pipe Plug, pl steel (not shown)	
116*	Reset Tubing Assembly (for Types 4166K & 4166KF)	
	Stainless steel	1H6866000A2
117*	Reset Tubing Assembly (for Types 4166K & 4166KF)	
	Stainless steel	1H6868000A2
194	Blowout Plug	
249	Bushing (not shown), 316 stainless steel	
	No lag extension	
	10 mm (3/8 in.) bulb diameter	
	14 mm (9/16 in.) bulb diameter	
250	Thermowell (not shown)	
256	Reset Restriction Valve Assembly	
	For Type 4166K	19A4361X012
	For Type 4166KF	19A4363X012
367*	O-Ring (2 req'd)	1C853806992
368	Machine Screw (2 req'd)	
369	Anti-Reset Windup Cover	
370	Washer(2) (2 req'd)	

*Recommended spare parts

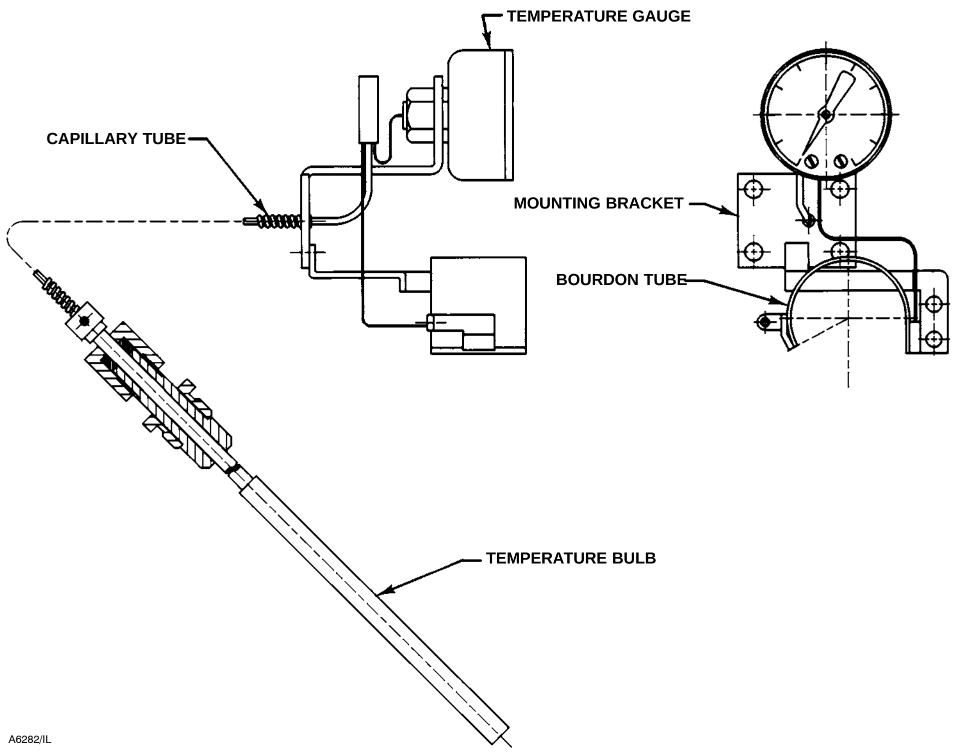


Figure 20. Temperature Element Assembly (key 78)

Mounting Parts (figure 3)

Note

Contact your Emerson Process Management sales office for part numbers not shown.

Key	Description	Part Number
213	Mounting Plate, steel	
	For yoke mounting on Types 470, 472, 513, 656, 657 & 667	1C221825022
	For yoke mounting on Type 480	
	Vertical	
	Horizontal	
	For yoke mounting on Types 1051 & 1052	
	Size 40 positions 1 & 3 w/switch and size 60 position 1 w/switch	23A8891X012
	All others	1C221825022
	For yoke mounting on Type 1061	
	Size 30 positions 1 & 3 w/switch and position 1 w/o switch, size 40 position 1 w/switch and sizes 80 & 100 position 3 w/o switch	23A8891X012
	All others	1C221825022
	For pipestand mounting	3N975725092
215	Machine Screw, steel pl (specify quantity req'd)	
	5/16 UNC x 1 inch	1C639128982
	5/16 UNC x 1-1/2 inch	1H304728982
	5/16 UNC x 2 inch	1C639228982
216	Hex Nut, steel pl (specify quantity req'd)	
	For filter regulator mounting on Types 1051, 1052 & 1061	1A352724122
	All other types and mountings	1C332828982
220	Mounting Bracket, steel pl (not shown)	
	For casing mounting on Types 657, 667, 1051 & 1052 and for casing mounted filter regulator on Types 1051 & 1052	1F401225072
221	Lockwasher, steel pl (specify quantity req'd)	1C225728982
222	Cap Screw, steel pl (specify quantity req'd)	
	5/16 UNC x 3/4 inch	1A381624052
	5/16 UNC x 1 inch	1A352624052
	5/16 UNC x 1-1/8 inch	1C379124052
	5/16 UNC x 1-1/4 inch	1B787724052
	5/16 UNC x 1-3/4 inch	1A553424052
	5/16 UNC x 2-1/2 inch	1C870224052
	5/16 UNC x 3-5/8 inch	1C398824052
	3/8 UNF x 1-1/8 inch	1A582824052
223	Cap Screw, steel pl (2 req'd)	
	Types 1051 & 1052 with either case or yoke mounted regulator and Type 1061 with yoke mounted regulator	T14109T0012
228	Spacer Spool, steel (specify quantity req'd)	
	Types 470, 472, 480, 513, 656, 657, 667, pipestand, 1051, 1052, & 1061	1F906724092
229	Cap Screw, steel pl (not shown) (specify quantity req'd)	
	Types 1051 & 1052 casing mounted controller	1A582824052

Key	Description	Part Number
238	Mounting Plate, steel	
	For yoke-mounted filter regulator	
	Types 1051, 1052 & 1062 sizes 40 & 60	1C221825022
	Types 1061 size 30	23A8891X012
240	Cap Screw, steel	
	For yoke-mounted filter regulator on	
	Types 1051 & 1052 sizes 40 & 60 (2 req'd)	1A553424052
241	Spacer Spool, steel	
	For yoke mounted filter regulators on	
	Types 1051 & 1052 sizes 40 & 60 (2 req'd)	1C559024092
242	Spacer Spool, steel (not shown)	
	For yoke mounting on	
	Types 1051 & 1052 size 40 (2 req'd)	1V102624092
	Type 1061 sizes 30, 80 & 100 (2 req'd)	1J830724092
250	Clamp, steel (2 req'd)	
	For pipestand mounting	1P427028982
251	Bracket Assembly, steel (2 req'd)	
	For panel or wall mounting	19B3107X012
252	Cap Screw, steel pl (4 req'd)	
	For panel or wall mounting	1B848024052

Note

Specify quantity of fittings.

Key	Description	Part Number
	Connector, brass	
	1/4 NPT x 1/4 O.D. tubing	1A636814012
	1/4 NPT x 3/8 O.D. tubing	1B885618992
	Elbow, brass	
	1/4 NPT x 1/4 O.D. tubing	1A397118992
	1/4 NPT x 3/8 O.D. tubing	1B884618992

4156K and 4166K Controllers

Emerson Process Management
Marshalltown, Iowa 50158 USA
Chatham, Kent ME4 4QZ UK
Sao Paulo 05424 Brazil
Singapore 128461

www.Fisher.com